GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN I.

Annual Administrative Report

OF THE

STATE GEOLOGIST

For the Year 1910

TRENTON, N. J.
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1911.

New Jersey State Geologist 12-7-119

The Geological Survey of New Jersey.

BOARD OF MANAGERS.

HIS EXCELLENCY J. FRANKLIN FORT, Governor and *ex officio* President of the Board, ...Trenton.

Members at Large.

DAVID E. TITSWORTH,	Plainfield,	1911
GEORGE G. TENNANT,	Jersey City,	1911
HARRISON VAN DUYNE,	Newark,	1912
CHARLES L. PACK,	Lakewood,	1913
JOHN C. SMOCK,	Trenton,	1913
ALFRED A. WOODHULL,	Princeton,	1914
FRANK VANDERPOEL,	Orange,	1914
T. FRANK APPLEBY,	Asbury Park,	1915

Congressional Districts.

I.	FREDERICK R. BRACE,*	Blackwood,	1911
II.	P. KENNEDY REEVES,	Bridgeton,	1912
III.	HENRY S. WASHINGTON,	Locust,	1914
IV.	WASHINGTON A. ROEBLING,	Trenton,	1913
V.	FREDERICK A. CANFIELD,	Dover,	1915
VI.	GEORGE W. WHEELER,	Hackensack,	1911
VII.	HERBERT M. LLOYD,	Montclair,	1912
VIII.	E. H. DUTCHER,	East Orange,	1914
IX.	JOSEPH D. BEDLE,	Jersey City,	1913
X.	CLARENCE G. MEEKS,	Weehawken,	1915

State Geologist,

HENRY B. KÜMMEL.

* Died May 5th, 1910.

Letter of Transmittal.

TRENTON, N. J., January 16, 1911.

Hon. John Franklin Fort, Governor and ex officio President of the Board of Managers of the Geological Survey:

SIR—I have the honor to submit my Administrative Report summarizing the work of the Geological Survey for the year 1910. This report is made in accordance with Chapter 46 of the Laws of 1910, and is not, as in previous years, accompanied by scientific papers. Several reports of the latter class are approaching completion, and, in accordance with the intent of the law cited above, will be submitted for publication in the near future.

Yours respectfully,

HENRY B. KÜMMEL,

State Geologist.

ADMINISTRATIVE REPORT.

HENRY B. KÜMMEL, STATE GEOLOGIST.

CONTENTS:

During the year ending October 31, 1910, the work of the Geological Survey was chiefly along the lines followed in previous years. The regular appropriation available was $16,500, which was supplemented by the sum of $830 carried over under contract from the appropriation of the previous year. The total expenditure aggregated $17,327.53, leaving a lapsed balance of $2.47.

The results of the work are briefly summarized herein. For more detailed results of the various scientific investigations the reader is referred to special reports on those subjects.

ADMINISTRATION.

Expenditures.—A tentative budget covering the expenditures of this money was approved by the Board of Managers early in the year, with authority to the State Geologist to modify it in detail as the exigencies of the work might demand. During the year the initiation of several new lines of work seemed advisable, so that the discretionary power lodged in the State Geologist was largely exercised.

The disbursements were as follows:

Salaries of State Geologist and scientific staff,	$11,284 15
Salaries of clerical assistants,	1,922 21
Traveling and field expenses,	1,150 68
Office furniture,	3 50
Office supplies,	302 30
Laboratory equipment,	65 65
Laboratory supplies,	447 26
Other scientific apparatus,	130 42
Library,	72 20
Museum supplies,	10 00
Postage,	333 18
Express,	144 95
Telegraph and telephone,	35 77
Engraving and printing maps,	1,425 26
	$17,327 53

Organization.—The appointment of the State Geologist and the general oversight of the Survey work is vested in the Board of Managers—one from each Congressional District and not more than ten at large, appointed by the Governor for terms of five years. Members of the Board receive no compensation, but are allowed the expenses incurred in discharge of their duties.

In April the following appointments were made by the Governor and confirmed by the Senate for terms expiring April 6, 1915: Frederick A. Canfield, Dover, re-appointment, Fifth Congressional District; Clarence G. Meeks, Weehawken, Tenth Con-

gressional District; T. Frank Appleby, Asbury Park, Member-at-Large.

Rev. Frederic R. Brace, Blackwood, representing the First Congressional District, died May 5, 1910. Mr. Brace had been a member of the Board since April 1, 1903. From the first he had shown a warm interest in work of the Survey and was rarely absent from the meetings of the Board. His wide acquaintance with the southern portion of the State made his counsel of particular value on all problems affecting that section, while his broad-minded interest in all that concerned the whole State prevented any trace of sectionalism.

The staff of the Survey shows but few changes from year to year. Six members, including the State Geologist, are continuously employed. The others are on a per diem basis and are engaged upon Survey work as the occasion demands. The following persons were employed during the last fiscal year:

Henry B. Kümmel, State Geologist.
R. B. Gage, Chemist.
Laura Lee, Clerk and Stenographer.
Howard M. Poland, Assistant in charge of collection of well data.
John S. Clark, General Assistant.
W. S. Bayley. Geologist.
J. Volney Lewis, Geologist.
E. W. Berry, Paleobotanist.
S. Percy Jones, Geologist.
W. B. Duryee, Jr., Assistant on Soil Survey.
Tunis Denise, Assistant on Soil Survey.
W. W. Oley, Assistant on Soil Survey.
H. D. Leslie, Assistant on Soil Survey.
W. W. Robbers, Assistant on Soil Survey.

C. C. Vermeule, Topographer and Consulting Engineer.
P. D. Staats, Topographer.
D. C. Stagg, Topographer.
Robert A. Lufburrow, Draughtsman.

John G. Baumann, Janitor at Laboratory.

Publications.—In March the Legislature enacted the following law governing the publication of the Geological Survey Reports:

"BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

"1. The State Geologist shall make to the Governor an annual administrative report of the operations of the Geological Survey. He shall also, from time to time, prepare, or cause to be prepared, such scientific reports as are pertinent to the work of his department. The State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed as submitted any or all such scientific reports. The cost of printing such reports shall be paid from the appropriation for printing public documents.

"2. This act shall take effect immediately."

This law specifically directs the preparation and printing of scientific reports pertinent to the work of the Survey and removes a doubt as to their legality, which had arisen in the mind of one member of the State Printing Board, in spite of existing legislation, the affirmative action of previous printing boards and a precedent extending over nearly fifty years. Promptly upon its passage, the printing of the report on Iron Mining, which had been held up for over six months, was authorized. The law now emphasizes the distinction between the annual administrative report of the State Geologist, which merely recounts the operations of the Survey, and is of only transitory interest, and the scientific papers, which are of permanent value. At a meeting held subsequently, the Board of Managers took cognizance of this separation and voted that the scientific papers which heretofore had appeared as parts of the Annual Report of the State Geologist in the future should be published as bulletins serially numbered, each under its own title, paging and index, the Administrative Report being a separate bulletin of this series. The bulletins will be bound in stiff paper or board covers, and the editions will vary in size as needed. It is expected that they will fall in one of the following classes:

a. Administrative.
b. Economic geology and mineral resources.
c. General and petrographic geology.
d. Paleontologic geology.
e. Water supplies.
f. Soil surveys.
g. Miscellaneous.

At the close of each year a small number of the administrative report and bulletins published during that year will be bound

together, as a "Year-book," but not re-paged and without an index of the entire volume. Owing to the limited editions of some bulletins, it will be impossible to send copies of all publications to everybody upon the mailing list. Those who have been receiving publications in the past are requested therefore to advise the State Geologist without delay what classes of reports are desired. Librarians, geologists and others whose interests may cover the entire field of the Survey publications may, upon request, receive either the separate bulletins as published or the "Year-book."

There are several advantages in this method of publication. Reports can be printed as soon as ready, without waiting until the completion of the fiscal year. It will be possible to reply to requests for information regarding certain topics with a report dealing with that subject alone, whereas, under the present system it is usually necessary to send a volume the major part of which deals with other matters. This will result in economy in printing, distribution and labor. Under this plan it is expected that there will be published during the coming year a report on the cost of a canal from Bay Head to the Shrewsbury River, the result of an investigation ordered by the last Legislature; a paper describing the fossil plants of the Raritan Clay beds, by E. W. Berry, which, while of interest to a comparatively small number of persons, is of great scientific value in the contribution it makes to our knowledge of the vegetation of the State during a far remote period; a summary of the quarrying and mining industry of the State with statistics of the mineral industry during 1910, to be prepared in co-operation with the United States Geological Survey.

During the past year the Survey has published the following reports and maps:

The Annual Report of the State Geologist for 1909. The Administrative Report was printed in January and laid before the Legislature. Advance copies of Part I, a Report upon the Development of the Passaic Watershed by Small Storage Reservoirs, by C. C. Vermeule, was printed early in the year for the Legislature. Later in the year the complete report was published and contained in addition to the papers mentioned

Part II. Record of Wells in New Jersey, 1905-1909, by H. B. Kümmel and H. M. Poland.

Part III. Notes on the Mineral Industry, by H. B. Kümmel.

A Report on Iron Mines and Mining, by Dr. W. S. Bayley, was also published, but not distributed during the year, owing to the necessary delay in completing the large geologic maps which accompany it. The report constitutes Volume VII of the final report series and is similar in size and make-up to the reports on Glacial Geology and the Clay Industry. It contains upwards of 500 pages, XIII plates and 31 text figures, in addition to two large geologic maps of the Highlands of the State showing the location of all known iron mines.

After a brief history of iron mining in New Jersey, there is a summary sketch of the geology of the State and a few words concerning the general character of the iron ores which comprise bog ore, limonite, hematite and magnetite. Each of these is in turn described as to nature of the ore, including appearance, chemical composition and metallurgical value, manner of occurrence, origin, distribution of deposits and detailed descriptions of individual mines. Naturally the chapters relating to the bog ores, limonite and hematite are short, for these deposits are relatively of little extent in the State and have yielded but meagerly in comparison with the great bodies of magnetite. The relative importance of the various ores is roughly indicated by the number of pages devoted to each—thus bog ores are described in eight pages, limonite in forty-two, hematite in twelve, and magnetite in 410 pages.

In connection with the origin of the magnetites, a subject about which there has been a great diversity of opinion among geologists, Dr. Bayley presents not only the present views as to their genesis, but has also exhaustively reviewed the literature and he gives a summary of the opinions of previous workers in this field as well as the conclusions reached by studies of magnetite deposits in other fields. He shows that the New Jersey magnetite occurs "1) disseminated as individual grains through the prevailing gneisses of the district; 2) as small bunches in these gneisses; 3) as an important component of some of the pegmatites associated with the gneisses; 4) as a prominent con-

stituent of certain zones in the Byram and Losee gneisses; 5) as an important component of certain layers of dark hornblendic rocks resembling the Pochuck gneisses in the direction of their banding; 7) as deposits of mixed magnetite, limonite and pyrolusite in the Franklin limestone; and 8) as irregular aggregates of magnetite, garnet and other silicates, and often some sulphides, associated with basic intrusive rocks in the limestone." The accumulations of magnetite having commercial importance are those in the pegmatite (3), those in the black gneisses (5) and those in the limestone (7 and 8). Most of the ore worked is of the fifth type, a mixture of hornblende, augite, feldspar, quartz and magnetite. In brief "the ores are regarded as being of magmatic origin—that is, the source of their material is thought to have been the deep-seated molten magmas portions of which, upon being intruded into the overlying rocks, solidified as the various gneisses now constituting the principal rocks of the Highland ridges. After the partial cooling of the gneisses these were in turn intruded by ferruginous portions of the same magma that gave them birth, and these intrusions were later enriched by iron-bearing solutions or vapors originating in the same subterranean source. In their transit to the surface these solutions or vapors deposited additional magnetite in the intruded ferruginous rocks and made the ore lenses that now comprise the ore bodies."

In connection with his discussion of the probable amount of ore reserves, Dr. Bayley points out that under this theory of origin there is nothing inherent in the nature of the ore or their method of origin to limit them below. In most cases of closed mines, operations ceased because the price of ore fell below the cost of mining and transportation, not because the ore body was worked out. Furthermore, only those ore bodies have been worked which outcropped or are continuations of those that outcropped. It is entirely reasonable to suppose that there must be ore bodies just below the surface which, because they do not outcrop, have not yet been discovered. The maps which accompany the report show many areas of high magnetic attraction[1] within

[1] Data for these areas were furnished by Mr. T. A. Edison, under whose direction much systematic magnetic exploration was carried on about sixteen years ago.

which there may be large undiscovered deposits of magnetic ore. From an inspection of these maps it would seem that there exists a very considerable reserve of ore which has not yet been touched. The total yield of ore during the past one hundred years or more (to the close of 1907) is estimated at about 22,522,000 tons, and Dr. Bayley declares that a conservative estimate of the quantity of good ore still capable of being mined from known deposits is 35,000,000 tons. These figures do not include a vast amount of lean ores, not now commercially available, which some day may be economically mined and concentrated and sent to market under other conditions.

In the descriptions of individual mines the author has availed himself of all data heretofore published. Practically every mine hole has been visited and every dump carefully examined, in the hope that some information on the occurrence and genesis of the ore might be found. All available analyses, some made for the report, have been collated and published, so that there is full information regarding the chemical composition of the ore.

Applications for the report should be addressed to the State Geologist with remittance of twenty-five cents for postage.

Maps.—During the year three sheets of the topographic atlas have been revised and reissued—No. 22, Eastern Sussex and Western Passaic counties; No. 23, Northern Bergen and Eastern Passaic, with the adjoining portion of New York State, and No. 29, the Monmouth Shore with the interior from Matawan to Lakehurst. In printing these maps an innovation was made in omitting the basal tint of buff which has heretofore been a distinguishing feature of this map series. As a result there has been a gain in clearness and ease in reading the map, particularly the fine figures showing elevations. Previous to publishing No. 29 it was necessary to re-engrave entirely the base, which was done on copper, as the required alterations were too extensive to be made upon the old stones. This was necessarily an expensive process and added much to the cost of the map, but seemed to be justified by circumstances.

It is highly probable that for some time to come a portion of the annual appropriation will have to be set aside for re-engraving the topographic base which in the case of many stones is becom-

ing so badly worn as to forbid further alteration. It is essential that each new edition of these maps be brought up to date, and this necessitates constant changes, particularly in the case of those maps covering the metropolitan and seashore sections. Up to a certain point these changes can be made upon the original engraved stones, but the limit is soon reached, particularly when the alterations include erasures as well as additions, for the surface of the stone becomes irregular, and it is impossible to obtain good impressions from it. Whatever new work of this nature is undertaken will be on copper rather than stone, as the first cost is not greatly dissimilar and alterations on copper can be more readily made.

Some criticism had been directed against the quality of paper on which the maps were printed on the ground that it lacked toughness. The matter was taken up with the engraver, and after some search a very superior grade of linen paper was obtained on a special order from mills in Germany. The new paper is somewhat lighter than that formerly used, but is much more durable and promises to give better satisfaction. Although its cost is considerably in excess of that formerly used, the increase is fully justified by the better quality.

Distribution.—The demand for the maps and reports of the Survey shows but little change from year to year. Topographic maps are sold at the uniform price of twenty-five cents per sheet, which includes postage, while the geologic folios range in price from twenty-five to fifty cents, postage extra. The reports of the Survey are distributed without charge, except in the case of some volumes for which payment of postage is required. By direction of the Board of Managers the last 200 copies of any report are sold at cost price. Copies of the following reports, available for free distribution have been exhausted, and they can now be obtained only by purchase:

Annual Report for 1883,	Price, $0 50
" " " 1892,	" 1 55
" " " 1903,	" 40

Paleontology, Vol. I—Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.

" " II—Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.

" " III—Paleozoic Paleontology, ...Price, $1 00

" " IV—Cretaceous Paleontology, ... " 2 70

Vol. II, Part 1—Mineralogy, Botany. Bound, price $1.50; unbound, postage 25 cents.

" IV—Report on the Physical Geography of New Jersey. Unbound, price, $1.00; bound, price, $1.35; photo-relief map, $1.50 extra.

The sale of maps by the Survey during the past three years is as follows:

	Sheets sold.		
	1908	*1909*	*1910*
Maps on scale of 1 inch per mile, ...	1637	1435	1485
Maps on scale of 2½ inches per mile, ...	1718	2205	2039
Geologic folios, ...	41	246	150
	3396	3886	3674

During the year 3,248 copies of the report for 1909 and 1,312 other reports, total 4,560, were distributed, as against 4,605 in 1909.

Library.—The Survey library continues to increase chiefly by exchange, but to some extent by purchase. It is becoming a serious matter to know how best to arrange it, as it threatens soon to overflow the limited space available. During the year the accessions were 42 bound volumes, 143 unbound, 54 pamphlets and 54 maps.

TOPOGRAPHIC WORK.

The topographic work, as in former years, has remained in charge of Mr. C. C. Vermeule. It has consisted almost entirely of revision of existing sheets, as no new surveys have been made.

Field work.—Considerable field work was necessary in revision of Sheets 30 and 34, in the southwest part of the State. These maps replace Nos. 10 and 14 of the old series and upon their completion the entire State will be covered by the newer one-inch per mile maps which do not overlap but meet edge to edge.

Office work.—Upon completion of the field work it was neces-

sary to make up copy of these sheets for use of the engraver. Inasmuch as both of these sheets include areas of Pennsylvania or Delaware, it seemed advisable to use for these portions data taken from the United States Geological Survey maps rather than to leave large portions of each sheet blank. It is believed that by so doing they are made more valuable to New Jersey users, as well as to inhabitants of the adjoining States. Considerable time also was spent in reading proof of new sheets Nos. 22, 23 and 29. Early in September, Mr. Vermeule began the preparation of the base for a new State map in two sheets on a scale of $\frac{1}{250000}$ or about four miles to an inch. The stones of the old five miles per inch base through repeated use and correction are in poor shape, so that the preparation of a new base is almost a necessity. The old base, moreover, because of multiplicity of detail, is poorly adapted for a geologic map, where colored patterns must be overprinted on the black base. The prospective publication of a new geologic map of the entire State, therefore, rendered the preparation of a new base necessary. The work involved is very laborious and three assistants were continuously employed during the balance of the year on this work, which was only partially completed. The new base will be engraved on copper, so that in the future alterations can be made upon it more readily than if it were on stone.

GEOLOGIC WORK.

Soil Survey.—As stated in my last annual report, the State Survey, in co-operation with the United States Bureau of Soils and the State Agricultural Experiment Station, is making a soil survey of portions of the State. Early in the spring work was carried on in the vicinity of Vineland, Millville and Bridgeton. Later the field party moved to Sussex County and continued the work begun the previous year. Field work was continued until about the first of December, when cold weather and snow caused its suspension. All of Sussex County, except a few square miles, has been covered and soil maps drawn. The field work has been very slow and painstaking and great care has been taken to make it accurate. After the various soil types had been studied and

differentiated over wide areas, they were carefully sampled for both chemical and physical analysis (see p. 26). Co-ordinately with the soil mapping, an agricultural canvass was carried on. Over 1,300 farmers in Sussex County were visited and information covering the following points was obtained.

QUESTIONS ASKED IN AGRICULTURAL CANVASS.

1. Name and address of owner or tenant, and time of occupation?
2. Area of farm, tilled land, untilled pasture, timber, meadow, if any?
3. Kind of soil and rotation of crops?
4. Methods of practices and number of acres in each crop: Corn, potatoes, wheat, rye, hay, oats, forage crops and pastures and truck.
   (a) Time and method of plowing? (b) Method of preparation, *i. e.*, how cultivated? (c) Variety of seed? (d) How and where is seed obtained? (e) Method of planting, distance between rows and in rows, if cultivated crops? (f) Method of seeding? (g) Quantity of seed?
5. Are green manures used? Cost of seed and labor?
6. Manures made and bought, and cost of manures bought?
7. How are home manures cared for, when applied and how much per acre?
8. Cost of fertilizers used? What kinds, how purchased, how applied? How much per acre?
9. Lime: Cost, kind, source. How much and how often applied?
10. Crops sprayed and methods of spraying?
11. Worst weeds and methods of eradication?
12. Cost of crops per acre: Highest, lowest and average yield per acre?
13. How are corn stalks, hay and straw cared for and used?
14. Live stock: Number of each breed of horses, cows, sheep, swine and poultry?
15. What kinds are raised and what bought?
16. Are soiling crops used? Kinds?
17. Silo: Kind, cost, efficiency? Crops used for silage?
18. Production of milk? Size of dairy and cost and method of handling?
19. Kind, character and amount of feeds bought?
20. Average annual yield of milk per cow?
21. Methods of disposal of crops: Transportation, markets, commission?
22. Labor: How much, and how employed? Cost?
23. Estimated values of annual sales?
24. Value of grange and other organizations in purchase of materials and sale of crops?
25. Are yields from the land increasing or decreasing?
26. Number of apple, peach, pear and cherry trees; yield of fruit; method of fertilization; spraying and marketing; income from trees?
27. Is the number of various fruit trees increasing or decreasing?
28. Average value of land per acre? Are values increasing or decreasing? To what extent?

INFORMATION TO BE SECURED AT CREAMERIES.

1. Name, location? Is it managed as a co-operative or private enterprise?
2. History of. When established? Changes in equipment and methods?
3. How much milk or cream is being handled?
4. What is the average distance through which milk is carried before it reaches the creamery?
5. On what basis are the patrons paid? Average amount of milk delivered by each patron?
6. What is done with skim milk?
7. What have been the fluctuations in the past ten years in the amounts of milk handled and the prices paid?

It is believed that, when this information has been tabulated and studied in reference to the physical and chemical composition of the soil types on each farm, it will be possible to draw most important conclusions regarding the needs and possibilities of the soils studied. A report upon the soils of Sussex County, with a soil map, will be published as soon as the data can be compiled.

As noted above this work is jointly carried on by the State Geological Survey, the State Agricultural Experiment Station, and the United States Bureau of Soils. The State Survey does a portion of the analytical work; defrays the field cost of the agricultural canvass and contributes to the field expenses of the soil survey.

Geologic map.—The last geological map of the entire State was published in 1890, and has been out of print for many years. Numerous large scale geologic maps of portions of the State have been published in connection with the reports of the Survey, and four folios of the final geologic atlas have been issued, and others are in preparation, but since this is a co-operative work with the Federal Survey, it will be a number of years before folios covering the entire State will be issued. Since there is a demand for a geologic map of the whole State on a moderate scale, it has been determined to prepare one on a scale of 1:250,000 or about four miles to an inch. This work will involve the engraving of a new geographic base as well as the preparation of the color stones showing the geology.

During the summer, Prof. J. V. Lewis was employed in compiling the geologic data for the map, while Mr. Vermeule and his assistants were at work on the geographic base. No new field surveys were necessary, but a vast amount of material had to be gone over carefully in order to incorporate all the corrections of the old base. Prof. Lewis's task was chiefly the transfer of the geologic boundaries from the field and office maps of various survey workers. It did not involve any new field work, although a few days were spent in the field with the State Geologist in an endeavor to obtain decisive data in a few regions where the relations are more than ordinarily complex.

Office work.—For many years the field work of the Survey outran the office work. As a result a vast amount of geologic information has been collected, much of which has never been properly compiled and published. More recently a larger part of the effort of the State Geologist and his assistants has been directed towards the compilation of these data and the preparation of reports. The geologic folios heretofore published and those in preparation are an expression of this side of the Survey's work. Until more of this accumulated data has been worked up it is not expected that any new lines of geologic investigation will be undertaken.

HYDROGRAPHIC WORK.

Underground waters.—The collection of data regarding the underground water supplies of the State has been in charge of Mr. H. M. Poland, and the plan of co-operation with the United States Geological Survey outlined in my last report has been continued. Between forty and fifty well drillers co-operate more or less fully with the department in furnishing data. During the year 104 new records and 37 sets of samples have been received.

I am in frequent receipt of requests for information regarding underground waters at various points in the State. Several well drillers often avail themselves of this opportunity to secure definite information regarding geologic conditions in regions where they are about to sink wells, particularly when operating in a region somewhat unfamiliar to them. During the past year,

also, I have received requests for information from two State institutions—the Rahway Reformatory and the Glen Gardner Sanatorium, both of which desired underground supplies. The Glen Gardner Sanatorium is located in the Highlands in the midst of the oldest rocks of the State—dense, crystalline gneisses. At the request of the Superintendent, I made an investigation of the geology of the Sanatorium grounds and vicinity, the results of which were embodied in the following letter:

TRENTON, N. J., April 12th, 1910.

Dr. S. B. English, N. J. Sanatorium for Tuberculous Diseases, Glen Gardner, N. J.:

DEAR SIR—At your request, I made, on April 11th, an inspection of the Sanatorium grounds to determine, so far as could be done by a surface examination, the possibilities of obtaining an adequate supply of artesian water. I beg to submit the following statement:

Geological Structure.—Numerous outcrops of a gray granite-gneiss occur along the ridge back of the Sanatorium. Similar rock was noticed in railroad cuts and a quarry near the railroad station at Glen Gardner. The same type of rock unquestionably underlies the lower fields both north and south of the central wooded ridge along which the ledges show, although on these lower slopes bed rock may be covered by 10 or 20 feet of stony soil.

In many sandstones the pore space is large, so that such rocks will absorb water to the amount of 20 to 40 per cent. of their volume. On the other hand, very few granites or granite-gneisses have a porosity exceeding 1 per cent. and the average is only one-half of one per cent. or lower. Practically all the water to be obtained from these rocks, therefore, is that present in the cracks and joints which traverse them. Observations on the ledges outcropping above the Sanatorium and elsewhere reveal at least two sets of joints at approximately right angles to each other and steeply inclined, and another set, approximately horizontal. In the quarry and railroad cuts the majority of these joints were dry, but a few carried some water. The only chance of obtaining water from wells in these rocks is by the boring intersecting one or more large cracks which carry considerable water or a sufficient number of small ones, each of which will contribute its share.

Previous Results.—A large part of Connecticut is underlain by rocks of similar character to those at Glen Gardner, and the results of 300 borings are on record. The yield varied from nothing to 200 gallons per minute, the average being about 15 gallons. Only three wells were reported as yielding more than 100 gallons per minute, and eight wells 60 to 100 gallons per minute, although the yield of several others is reported as "good," "large" or "very large." About 10 per cent. yielded less than 2 gallons per minute.

In New Jersey very similar results have been obtained. Of twelve wells drilled in gneiss and granite near Bernardsville, the average yield was only 15 gallons per minute, although one well was reported to give 100 gallons per minute. I therefore conclude that the chances of obtaining a supply sufficient for the Sanatorium from a single well, while not impossible, are very remote,

probably not one in sixty. The probabilities of a sufficient supply from a number of wells is, of course, better, but it must not be forgotten that 10 per cent. of the wells drilled in Connecticut yielded less than 2 gallons per minute.

Flowing Wells.—Very rarely indeed is a flowing well obtained in these rocks. In the Connecticut wells, so far as recorded, the water stood at heights varying from a little above the surface in the case of flowing wells to 100 feet below. It is almost certain that pumping would be necessary in any well drilled at Glen Gardner.

Pumping from Wells vs. *Pumping a Surface Supply.*—In a system of rock wells the water might not rise high enough to permit its being carried by gravity to a receiving tank from which it could be pumped to the reservoir. If this should prove to be the case, it would be necessary to pump directly from the wells. If the total capacity of the wells was only slightly in excess of the requirements of the institution, continuous pumping would be necessary, day and night. Under present conditions I understand that it is necessary to pump only at intervals during the day, which is, of course, much more economical.

Number of Wells Necessary.—If only the average amount of water (15 gallons per minute) was obtained from each well, it would be necessary to put down four wells to obtain the 65,000 gallons per day which I understand is needed and to allow 25 per cent. excess for emergencies.

Depth of Wells Necessary.—The Connecticut wells range from 15 to 845 feet in depth. The deepest of those in New Jersey of which I have record are a little over 700 feet. Experience has shown that the most ample supplies are usually (though not exclusively) found within 250 feet of the surface. Below that depth the chances of obtaining water decrease. Since the cost of drilling also increases with depth, it is usually better not to continue a boring in this rock below 250 or 300 feet. If water has not been obtained within that depth it is usually better to try another hole elsewhere than to continue the old one.

Cost of Drilling.—The cost of a well in this rock will probably be between $4.00 and $5.00 per foot.

Location of Borings.—If it be deemed advisable to make tests, I would say that so far as any surface indications go there is very little choice of location, so long as the rocky, wooded ridge back of the Sanatorium be avoided. I would recommend the lower slope well removed from this ridge and not too close to the present springs, if it be desired to avoid interference with them.

Quality of Water.—Water obtained from rocks through which it has passed in open cracks is more readily polluted from surface sources than water obtained from deep sand beds. In this particular case, however, the risk of pollution is probably no greater than to the water now being obtained from the shallow springs. Water from deep rock wells may contain slightly more mineral matter than that now used, but in the absence of limestone in this region I do not believe it will be hard enough to prove objectionable.

In view of the many uncertainties connected with an underground supply in these rocks, my opinion is that if a satisfactory surface supply can be obtained, it would probably be better not to incur the risk of failure in boring.

Yours truly,

HENRY B. KÜMMEL,
State Geologist.

Subsequently the ground was examined by a self-styled "specialist in hydrogeology," who by the aid of a radio-sensitive hydroscope[1] of his own design claimed to be able to locate the occurrence of large streams of underground water. Later a well was drilled at the spot chosen by the "specialist" with the aid of this modern modification of the old witch-hazel divining rod. A twenty-four-hour pumping test was made on the well on November 1, when the boring had a depth of 500 feet. At the beginning of the test the water stood in the well at a depth of 27 feet from the surface. After the first five hours of pumping the water level sank from 27 to 220 feet from the surface, where it remained constant during the remainder of the test (19 hours). After this constant water level was reached the yield was 16 gallons per minute or about 23,000 gallons per day continuous pumping or only one-third of what is needed. Previously a 5-hour test had been made at a depth of 138 feet, the yield then being 20 gallons per minute. A second test, 5-hour pumping, was made at a depth of 195 feet, resulting in a yield of 23 gallons. It appears, therefore, that there was no increase in the amount of water in the latter 250 or 300 feet on the well.[2]

In this connection it cannot be too strongly emphasized that there are no devices, electrical, radio-active, or of any character whatever, which can be used to determine the occurrence of

[1] Of this "hydroscope" an eminent authority in radio-active phenomena has expressed the opinion that "the witch-hazel rod was probably the more scientific instrument," and that there was no way that he knew of "by which there is any reasonable probability that deep water could be discovered by its radio-active properties."

[2] Since the above paragraphs were written, and while the report is in the hands of the printer, I have been advised that the well was subsequently deepened to 604 feet, the water standing 22½ feet from the surface, and on pumping the well yielded 20 gallons per minute. In order to increase the yield 650 lbs. of powder were exploded at the bottom and 350 lbs. at a depth of 328 feet. The water-level then dropped to 33½ feet from the surface. A 48-hour continuous pumping test was made, the yield for 20 hours being 42 gallons per minute and for 28 hours from 63 to 66 gallons per minute. At the conclusion of the pumping test the water-level stood at 82 feet from the surface. Subsequently two additional shots were fired, 350 lbs. of powder at 450 feet and 150 lbs. at 225 feet. Their effect has not been reported to me, but the supply as shown by the tests already made is a great improvement over that previously had.

underground water. The devotee of the time-honored witch-hazel twig and the pseudo-scientist with his recent invention and jumble of scientific terms designed to impress the non-technical man are alike conscious or unconscious fakers. That in many localities the occurrence of ground water is indicated by surface conditions is a fact known to all; that the manipulator of the witch-hazel and all other water-finding devices consciously or subconsciously notes these signs and "works" the device accordingly is unquestionably the explanation of many apparently successful instances of their use, and the fact that in some regions a well dug at any point will furnish abundant water is explanation of other seemingly successful attempts. Much emphasis is laid upon the cases where water has apparently been located by their use. Nothing is ever said of the numerous instances where they have been absolute failures.

At the Rahway Reformatory a flowing well was obtained in the red shale formation (Triassic) at a depth of 490 feet (total depth 504 feet), the water having a five-foot head above ground and flowing at the surface 35 gallons per minute. On pumping 125 gallons per minute for 15 minutes the water is lowered 150 feet, the yield being maintained at 62 gallons per minute at that depth. Analysis by the State Board of Health showed the water to be extremely hard—2,041 parts of total solids in 1,000,000, and having a total hardness of 310. Sodium sulphate and a compound of magnesium were present in considerable amount.

Surface supplies.—No additional studies of the surface supplies of the State have been made during the year. The drought which prevailed during much of the summer and fall placed a severe strain upon many reservoirs and in some cases drew them down beyond the safety limit. The shortage of water in many communities emphasized the importance of the wise solution of this problem, but it is important that the lessons of the year should be correctly learned and the facts not misinterpreted. There was nothing in the experience of the year to invalidate to the slightest degree the conclusions of the Survey, based upon long and careful study of the streams of the State, that the aggregate amount of potable surface water is far in excess of

the present needs of the State and of all future needs for many, many years to come, even though the population increases in density far beyond any reasonable anticipation.

The lesson, as I interpret it, is the necessity of providing reserve supplies sufficient to meet such droughts as previous experience, evidenced by the records of the Weather Bureau, give us the right to expect. These should be provided in storage reservoirs of sufficient capacity to meet the demands of the severest drought there is any reason to expect, or in case of underground supplies, in the development of new territory by additional wells sufficiently in excess of ordinary demands to meet such emergencies. The fact that several large water companies of the State were hard put to meet the legitimate demands of the communities dependent upon them was due entirely to a failure to provide the necessary reserves which rapidly growing communities and annual variations in rainfall make absolutely necessary. It was not due to a shortage of surface supplies, for there are many streams as yet undeveloped, and even on those watersheds now utilized the storage capacity provided is in most instances far less than necessary to develop the total capacity of the watershed.

Inasmuch as several communities in the northern part of the State are, or will be, in need of additional supplies in the near future, I wish to call attention to the possibility of the further development of the upper Passaic watershed by means of several small reservoirs constructed from time to time as necessity demands. This plan was worked out in much detail in the report by Mr. C. C. Vermeule published in the Annual Report of the State Geologist for 1909. It was accompanied by a map showing the location of existing and proposed reservoirs, and the sources of supply of the various portions of the Metropolitan district. The question of an adequate and economical development of the water resources of the State is so great and contains so many diverse factors, that it needs to be examined from all points of view, and every possible means of solution thoroughly tested. In the final solution of the problem the suggestions set forth in that report should certainly have great weight.

CHEMICAL WORK.

Mr. R. B. Gage has continued in charge of the chemical laboratory, with F. H. Baumann and J. Clifford Wilkes as assistants, the latter being employed during the busy season from June 10 to Sept. 10. The major part of the work undertaken has been the analyses of soils, road oil and asphalt, although some work on minerals has been done.

Soil Analyses.—The chemical analyses of soils collected in progress of the soil survey is a part of the contribution of the Survey to the co-operative work which is being carried on in conjunction with the United States Bureau of Soils and the State Agricultural Experiment Station. During the year about seventy-five complete soil analyses have been made, many of them in duplicate and each consisting of at least sixteen separate determinations, so that about 1,200 determinations have been made and reported and probably 800 others made as checks or duplicates. This work has been very carefully done, and much time and attention given to small quantities of certain compounds or ingredients which may or may not be present. Owing to the fact that the work has to be done in a building not designed for a laboratory and under conditions which are far from favorable to accurate results, much time is consumed in precautions to guard the work from error—precautions which would be unnecessary in a properly constructed laboratory.

As the work progressed it seemed advisable to modify some of the commonly accepted methods of soil analysis to secure a greater degree of accuracy and save time, while in some cases new methods for this line of work have been devised. Some new forms of apparatus have been designed and found to be very efficient and accurate. It was necessary, however, to subject all these methods and apparatus to thorough tests on all the various types of soil before they could be adopted. This demanded much work, which will not have to be repeated, but the time spent will be more than saved before the entire work is completed.

Minerals.—A few analyses of miscellaneous substances have been made for private persons upon payment of a fee equivalent

to that charged by commercial laboratories. The Survey does not solicit work of this character, but it is frequently called upon to make anaylses of water, ore, etc., by persons who either assume that the gratuitous analysis of any ore for a citizen of the State is one of the regular functions of the Survey, or, expecting to pay a fee, have more confidence in an analysis made in an official laboratory, or who do not know a reliable chemist or assayer to whom to apply. Generally the applicant is referred to a private laboratory. Occasionally when the analysis can be made without interfering with the regular work it is done and a fee charged. In rare instances it is made without charge, when the results seem to be of value to investigations of the Survey already undertaken. In all such cases the right to use the results as may seem desirable in Survey work is reserved.

Mr. Gage has also been called upon to make a number of analyses of rare or obscure minerals to determine their identity, material for this purpose being received from the mineral collections of Harvard and Princeton Universities, Rutgers College, the American Museum of Natural History and from the large collection of Col. Washington A. Roebling of Trenton, as well as from other mineralogists. This work has resulted in the discovery of at least one new mineral and probably two others. Justification for work of this semi-private character is found in the possibility that new minerals may thereby be discovered. It does not involve the analysis of every mineral which may be presented at the laboratory, but is restricted to those rare, peculiar or unknown forms which may be new to science. The Survey reserves the right of publication of these results if it seems advisable.

The new mineral[1], the existence of which has been demonstrated, occurs on leucophoenicite from Franklin Furnace, associated with the typical minerals of that region, crystalline zincite, green willemite and calcite. Owing to the extremely

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[1] A preliminary note of this mineral was published by Alexander H. Phillips, of Princeton University, in the American Journal of Science for October, 1910, Series 4, Vol. XXX, p. 283, and the name *gageite* proposed. It is hoped that later Prof. Phillips will be able to measure its crystal faces and angles.

minute size of the crystals and their scarcity, it was a matter of much difficulty for Mr. Gage to obtain enough for a chemical anaylsis. Finally, through the co-operation of Col. W. A. Roebling, about .04 of a gram were obtained and analyzed by him with the following results:

				Ratio.
SiO_2,	24.71	.412		1.49
MnO,	50.19	.707		
ZnO,	8.76	.107	1.109	4.00
MgO,	11.91	.295		
H_2O,	(4.43)	.224		0.9

This yields the formula $(RO)_8\ (SIO_2)_3\ .2H_2O$. "The crystals are clear and colorless, with a high vitreous luster, delicate, acicular and hair-like, often radiated and grouped in bundles extending out from the wall of small cavities, not unlike the habit of millerite."

It is anticipated that these mineralogical studies will yield enough material to justify the publication during the coming year of a bulletin relating solely to them.

Oils and asphalts.—Co-operation with the State Road Commissioner in the examination and testing of oils and asphalts used in road construction has continued. Upwards of 325 samples of these materials were analyzed during the year, in the course of which 1,200 separate determinations were made. The importance of having these oils and asphalts thoroughly tested and their value for road building established before they are used on the road has been very plainly demonstrated during the past year. Not all oils or asphalts will make good roads. The cheaper ones are naturally of the lowest grades and least desirable. but are the ones the contractors would naturally use, if the selection of these materials was left to their discretion, since it would mean an additional profit. It is next to impossible to distinguish between these various bitumens unless they are analyzed. If the cost of construction and maintenance of the improved roads of New Jersey per year be considered, the amount of money required to test the oils and asphalts used in their construction is so small that it is almost negligible. If the life of a single mile of road

has been doubled by these tests, the total cost of testing the oils and asphalts used during the entire year on all the roads of the State will be far more than repaid. A rough idea can thus be secured of the saving to the State by being sure in advance of the quality of the material which is used in the construction of this type of road.

The expense of this work is defrayed in large part by the State Road Commissioner, from whose appropriation there are paid the salaries of the assistants making the analyses, but in so far as Mr. Gage has given his personal attention to this work, there has been a charge upon the Geological Survey appropriation. This charge has in part been compensated for by the help in soil analyses received from the assistants when the demands of the oil work were not pressing.

The purchase and testing of coal.—A large part of the coal now used by the United States Government is purchased on specifications involving the number of heat units contained therein, and is paid for on a sliding scale based upon the heat units, per cent. of ash, sulphur, etc. Many of the commodities of life have long been purchased according to specifications requiring chemical or physical tests or both to determine whether the material delivered meets the requirements, but until recent years coal has been purchased merely on the statement of the dealer as to its quality. Reliance has been placed on his integrity and on the reputation of the mine or district from which the coal was obtained. This practice still prevails among all small purchasers, but many large corporations and the National Government have adopted specifications providing for scientific tests of the coal purchased and its payment on a sliding scale according to quality. The advantages of this method are manifest, the purchaser pays for what he gets and gets what he pays for. The dealer receives a higher price for superior grades of coal and is penalized for inferior grades. The poorer coals find a market by competing with the better grades, not as to price per ton, but as to the cost of an equal number of heat units.

The most valuable coal is one which gives up the most heat for a given weight burned. Some of the factors determining its value are moisture, ash, sulphur and clinker, volatile gases and

fixed carbon. These vary within considerable limits even in commercial coals of recognized standing, and the variations all have their bearing on the heating power of the coal.

Moisture.—Coal as mined contains more or less moisture, and in shipment it may be either dried out or drenched by rain. If in a ton of coal the moisture equals 5 per cent (a not unusual amount for some grades), the purchaser buys 100 lbs. of water with every ton, which not only cannot burn, but which consumes in its evaporation a very considerable part of the heat produced when the coal is burned, and on which freight and cartage has been paid.

Ash.—Earthy matter and other impurities which will not burn are classed as ash. In commercial coals the proportion of ash may range from *4 to 25 per cent.* It is manifest that coals containing small amounts of ash have higher heating capacity than those high in ash. They also offer less resistance to the free distribution of air through the fire, and the added expense of handling large amounts of ash must not be overlooked. With an ordinary furnace equipment there is a considerable loss of efficiency and capacity with a large percentage of ash. In some experiments coal containing as high as 40 per cent of ash would generate no steam. Under the conditions of the experiment such coal would be not only worthless, but its use would involve a direct expense due to the cost of handling it.

Sulphur in coal with other impurities often forms a clinker which clogs the grates, shuts out the air and increases the labor of handling the furnace. Hence coals low in sulphur are regarded as the more desirable.

The coal bill of the various State Institutions of New Jersey is upwards of $125,000 per annum. In the past none of this coal has been purchased under specifications providing for a test of its heating properties. In view of the advantage which it is believed would result in the application of a more exact method of purchase the Board of Managers of the Survey has directed the State Geologist to co-operate with any State Institution desiring to purchase coal under a more exact plan. The Survey will, when requested, assist in drawing up the necessary specifications and will make the required tests of the coal as it is

delivered. This will be done without cost to the institutions, except that the sampling must be done by an officer of the institution and the reduced sample forwarded to the Survey laboratory. In beginning this work, it will be restricted at first to anthracite coal, since facilities at present available at the Survey laboratory for this work are rather limited. and the testing of anthracite is more readily done than bituminous

INLAND WATERWAY SURVEY.

On April 6, 1910, the Legislature passed the following concurrent resolution:

"WHEREAS, The construction of the inland waterway along the New Jersey coast has already shown in a marked degree the advisability of such an improvement; and

"WHEREAS, There is a general demand that the same be continued by means of a canal from Bay Head in Ocean county to the Shrewsbury River in Monmouth county; therefore be it

"*Resolved* by the House of Assembly (the Senate concurring), That the State Geologist be directed from such data as may be in his possession to ascertain the approximate cost of the construction of a sea-level canal, with minimum depth of six feet and minimum width at the water level of sixty feet between Bay Head and the Shrewsbury River, and to report thereon at the next session of the Legislature.

"*Resolved,* That the Governor be authorized to appoint two competent residents of the State, who shall estimate the value of the real estate necessary to be taken for the line of such canal, their estimate thereon to be incorporated in the report of the State Geologist."

It will be noted that the resolution did not carry with it any appropriation of money, nor did it direct or authorize any survey of a canal route. It directed only the preparation of an estimate made up from data already in the posession of the survey. This data consisted of published topographic maps on a scale of 2,000 feet per inch, with contour intervals of 10 feet, manuscript geological maps of the rock formations and well borings showing strata. There was also a detailed report of the cost of a canal for a part of the route, namely from Bay Head to Manasquan Inlet, made in 1903.

Although no funds were appropriated specifically for this work, a small part of the regular Survey appropriation was avail-

able for incidental expenses in this connection. The most available route was located upon the topographic maps, and afterwards checked by field inspection. A profile of the route was then taken from the topographic map and the amount of excavation calculated.

Full details of the route, cost, etc., so far as they can be determined in a preliminary estimate of this character, are given in a separate report which is accompanied by maps and sections. It is sufficient to state here that the estimated excavation amounts to over 7,000,000 cubic yards; the cost of excavating and disposal of material from $970,000 to $1,758,000, according to plan adopted; drawbridges about $380,000 and right-of-way, including land for dumping, $200,000 to $400,000, administration, engineering, legal and contingent expenses 10 per cent., making a total of $2,152,000 to $2,784,000. Reference is made to the special report for fuller details. It must be understood that this line of inquiry was not initiated by the Survey, but was undertaken in response to the direction of the Legislature.

CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

The State Survey co-operates with the United States Geological Survey in the publication of geologic folios, which are parts of the geologic atlas of the State, in the collection and recording of well data and in the collection of mineral statistics. During the past year, however, the co-operative work in statistics was by mutual agreement suspended owing to taking the National census, which made it incumbent upon the United States Survey to work in harmony with the Census Bureau. Under the circumstances, it did not seem best for the State Survey to duplicate the statistical work in all lines, but data regarding the production of iron-ore, zinc-ore, cement and limestone for 1909 were obtained and the results published in the report for 1909, which was somewhat delayed in printing.

The statistics for 1910 will be collected in co-operation with the United States Geological Survey and made public in a special bulletin to be printed as soon as the full returns can be collected.

The results of co-operation in collecting the well records have

already been mentioned (see p. 20). The method pursued is fairly effective, provided it is constantly followed up by personal visits to the drillers and by inspection of the work to insure correct records and the saving of samples. This Mr. Poland has been able to do in large measure.

NEEDS OF THE SURVEY.

The greatest need of the Survey is better accommodations for carrying on its work. The offices provided in the State House are as large as the crowded condition of that building will permit, but they are entirely inadequate for the proper conduct of this department. The general office is shared with the Forest Commission. The office of the State Geologist, a small room, is also the library and is crowded with book shelves and filing cases. The vault, containing valuable records to which more or less frequent reference has to be made, is on another floor of the State House, off a room belonging to the Supreme Court Clerk's suite. Two assistants occupy a small room in the basement so dark that artificial light must always be used. Still another assistant has a desk in an obscure corner of the basement surrounded by discarded voting machines and junk of various kinds. The reports and collections of the Survey are stored in three different sections of the basement. In the aggregate, the storage room is fairly adequate, but its diffusion adds greatly to its inconvenience. Year by year the chemical laboratory has become of increasing importance. For several years it has occupied and still occupies, through the courtesy of Col. Washington A. Roebling, one of the Board of Managers of the Survey, the second story of a building several blocks removed from the State House. The building is but poorly adapted for a chemical laboratory, but is the best obtainable at present and has been made to serve our purpose. However, as the Survey is a tenant only by courtesy of the owner, its occupancy of these quarters can be regarded at best as only a temporary expedient until something better can be provided. It seems hardly consonant with the dignity of the State that it should have to depend upon the generosity of a private citizen for accommodations for one of its departments.

The work of a scientific bureau for investigation and research cannot be successfully carried on under conditions which may be satisfactory for business and administration. Those engaged in research must have adequate laboratory and office room where experiments can be conducted under conditions favorable to accurate results, and where reports can be prepared free from interruption. The writer knows of no State Survey so poorly provided with suitable quarters for its work as is the New Jersey Survey. The support afforded the Survey both in annual appropriations and provision for printing its results has always been generous and hearty. No state has ever done so much for so many years in proportion to its size. The next step is an appreciation of the needs of the Survey in the way of larger quarters, better adapted to our work, and designed to bring closer together the widely separated branches of the department.

PUBLICATIONS.

The appended list makes brief mention of all the publications of the present Survey since its inception in 1864, with a statement of the editions now out of print. The reports of the Survey are distributed without further expense than that of transportation. Single reports can usually be sent more cheaply by *mail* than otherwise, and requests should be accompanied by the proper postage as indicated in the list. Otherwise they are sent *express collect. When the stock on hand of any report is reduced to 200 copies, the remaining volumes are withdrawn from free distribution and are sold at cost price.*

The maps are distributed only by sale, at a price, 25 cents per sheet, to cover cost of paper, printing and transportation. In order to secure prompt attention, requests for both reports and maps should be addressed simply "State Geologist," Trenton. N. J.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY. Newark, 1868, 8vo., xxiv+899 pp. Out of print.

PORTFOLIO OF MAPS accompanying the same, as follows:

1. Azoic and paleozoic formations, including the iron-ore and limestone districts; colored. Scale, 2 miles to an inch.
2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey; colored. Scale, 2 miles to an inch.
3. Cretaceous formation, including the greensand-marl beds; colored. Scale, 2 miles to an inch.
4. Tertiary and recent formations of Southern New Jersey; colored. Scale, 2 miles to an inch.
5. Map of a group of iron mines in Morris County; printed in two colors. Scale, 3 inches to 1 mile.
6. Map of the Ringwood iron mines; printed in two colors. Scale, 8 inches to 1 mile.
7. Map of Oxford Furnace iron-ore veins; colored. Scale, 8 inches to 1 mile.
8. Map of the zinc mines, Sussex County; colored. Scale, 8 inches to 1 mile.

A few copies can be distributed at $2.00 per set.

REPORT ON THE CLAY DEPOSITS of Woodbridge, South Amboy and other places in New Jersey, together with their uses for firebrick, pottery, &c. Trenton, 1878, 8vo., viii+381 pp., with map. Out of print.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi+233 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi+439 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8vo., x+642 pp. Unbound copies, postage, 25 cents. Bound copies, $1.50.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x+824 pp. (Postage, 30 cents.)

REPORT ON WATER-SUPPLY. Vol. III. of the Final Reports of the State Geologist. Trenton, 1894, 8vo., xvi+352 and 96 pp. (Postage, 21 cents.)

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol. IV. of the Final Reports of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp. Unbound copies, $1.00; cloth bound, $1.35, with photo-relief map of State, $2.85. Map separate, $1.50.

REPORT ON THE GLACIAL GEOLOGY of New Jersey. Vol. V. of the Final Reports of the State Geologist. Trenton, 1902, 8vo., xxvii+802 pp. (Sent by express, 35 cents if prepaid, or charges collect.)

REPORTS ON CLAYS AND CLAY INDUSTRY of New Jersey. Vol. VI. of the Final Reports of the State Geologist. Trenton, 1904, 8vo., xxviii+548 pp. (Sent by express, 30 cents if prepaid, or charges collect.)

BRACHIOPODA AND LAMELLIBANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp. 338, plates XXXV. and Map. (Paleontology, Vol. I.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, Plates L. (Paleontology, Vol. II.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.)

PALEOZOIC PALEONTOLOGY. Trenton, 1903, 8vo., xii+462 pp., Plates LIII. (Paleontology, Vol. III.) (Price, $1.00.)

CRETACEOUS PALEONTOLOGY. Trenton, 1907, 8vo., ix+1106 pp., Plates CXI. (Paleontology, Vol. IV.) (Price, $2.70.)

ATLAS OF NEW JERSEY. The complete work is made up of twenty sheets, each about 27 by 37 inches, including margin. Seventeen sheets are on a scale of 1 inch per mile and three on a scale of 5 miles per inch. It is the purpose of the Survey gradually to replace Sheets 1-17 by a new series of maps, upon the same scale, but somewhat differently arranged so as not to overlap. The new sheets will be numbered from 21-37, and will be subject to extensive revision before publication. These sheets will each cover the same territory as eight of the large maps, on a scale of 2,000 feet per inch. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16 and 17 have already been replaced as explained below.

No. 10. Vicinity of Salem from Swedesboro and Bridgeton westward to the Delaware.

No. 14. Vicinity of Bridgeton, from Allowaystown and Vineland southward to the Delaware Bay shore.

No. *19. New Jersey Relief Map.* Scale, 5 miles to the inch. Hypsometric.
No. *20. New Jersey Geological Map.* Scale, 5 miles to the inch. (Out of print.)
No. *21. Northern Warren and Western Sussex counties.* Replaces Sheet 1.
No. *22. Eastern Sussex and Western Passaic counties.* Replaces Sheet 4.
No. *23. Northern Bergen and Eastern Passaic counties,* to West Point, New York. Replaces northern part of Sheet 7.
No. *24. Southern Warren, Northern Hunterdon and Western Morris counties.* Replaces Sheet 2.
No. *25. Morris and Somerset counties,* from Lake Hopatcong to Somerville and New Brunswick. Replaces Sheet 6.
No. *26. Vicinity of Newark and Jersey City*—Paterson to Perth Amboy. Replaces in part Sheet 7.
No. *27. Vicinity of Trenton*—Raven Rock to Palmyra, with inset, Trenton to Princeton. Replaces Sheet 5.
No. *28. Trenton and Eastward*—Trenton to Sayreville. Replaces Sheet 8.
No. *29. Monmouth Shore,* with the interior from Ernston to Lakehurst. Replaces Sheet 9.
No. *31. Vicinity of Camden,* to Mount Holly, Hammonton and Elmer. Replaces Sheet 11.
No. *32. Part of Burlington and Ocean counties,* from Pemberton and Whitings to Egg Harbor City and Tuckerton. Replaces Sheet 12.
No. *33. Southern Ocean County*—Tuckerton to Tom's River and Chadwicks. Replaces Sheet 13.
No. *35. Vicinity of Millville,* from Newfield to Port Norris and Cape May Court House.
No. *36. Parts of Atlantic and Cape May counties*—Egg Harbor City to Townsend's Inlet, with inset of New Inlet and Great Bay.
No. *37. Cape May*—Cape May City to Ocean City and Mauricetown.
No. *38. New Jersey State Map.* Scale, 5 miles to the inch. Shows all municipalities.

Other sheets of the new series, Nos. 21–37, will be printed from time to time, as the older sheets become out of print. All the maps are sold at the uniform price of twenty-five cents per sheet, either singly or in lots. Since the Survey cannot open small accounts, and the charge is merely nominal, remittance should be made with the order. Order by *number* of the State Geologist, Trenton, N. J.

TOPOGRAPHIC MAPS, NEW SERIES.

These maps are the result of recent revision of the earlier surveys, and contain practically all of the features of the one-inch scale maps, with much new material. They are published on a scale of 2,000 feet to an inch, and the sheets measure 26 by 34 inches. The Hackensack, Paterson, Boonton, Dover, Jersey City, Newark, Morristown, Chester, New York Bay, Elizabeth, Plainfield, Pluckemin, Amboy, New Brunswick, Somerville, Navesink, Long Branch, Shark River, Trenton, Camden, Mt. Holly, Woodbury, Taunton and Atlantic City sheets have been published and are now on sale. The price is twenty-five cents per sheet, *payable in advance.* Order by *name* any of the sheets above indicated as ready, of the State Geologist, Trenton, New Jersey.

GEOLOGIC ATLAS OF NEW JERSEY.

The State Geological Survey, in co-operation with the U. S. Geological Survey, is engaged in the publication of a Geologic Atlas of New Jersey. It will be issued in several parts, each part containing a complete discussion of the geography and geology for the region covered. Each volume will comprise (1) pages of descriptive text, (2) a topographic map, (3) geologic maps showing the distribution and structure of the various rock formations, the occurrence of all mineral deposits of economic importance, and (4) in some cases pages of half-tone illustrations. The following folios are now ready:

THE PASSAIC FOLIO, which covers the region from Morristown to Jersey City, and from Perth Amboy and New Brunswick to Pompton and Westwood, comprising 945 square miles; scale, 2 miles to an inch. It includes 27 pages of text, a topographic map, 3 geologic maps and a page of illustrations. Price, 25 cents; postage, 15 cents; if sent by express, charges collect.

THE FRANKLIN FOLIO covers the territory from Branchville and Newton, on the west, to Stockholm on the east, and from Andover and Petersburg, on the south, to Libertyville on the north, or 235 square miles; scale, 1 inch to a mile. In addition to the regular text and maps it includes a special study and description of the famous zinc deposits at Franklin Furnace, and of the white crystalline limestones. Price, 25 cents; postage, 15 cents extra; if sent by express, charges collect.

THE PHILADELPHIA FOLIO covers parts of New Jersey and Pennsylvania adjacent to Philadelphia. It is a double folio (scale, 1 inch per mile), having four topographic maps, four geologic maps, two maps showing, by means of cross sections, the geological structure and the relation of the various rock formations to each other below the surface, a page of illustrations and twenty-four pages of descriptive text. Price, 50 cents; postage, 15 cents extra; if sent by express, charges collect.

THE TRENTON FOLIO describes the region around Trenton as far as Stockton, Millstone, Hightstown, New Egypt, Mount Holly, Delanco and Newtown, Pa., an area of 911 square miles. It contains descriptive text and three maps (scale, 2 miles per inch). It is published in two forms, the folio size (21¾ by 18½ inches) and a pocket or octavo size (9¼ by 6 inches). In the latter the maps are on thin paper, are folded and in a pocket. This size is more convenient for field use than the folio size. Price, folio edition, 25 cents, postage 15 cents extra; pocket edition, 50 cents, postage 10 cents extra. If sent by express, charges collect.

Other folios will be prepared and issued from time to time until the entire State is covered.

Orders for these folios should be addressed to the State Geologist, Trenton, N. J., and *remittance must accompany the order.*

ANNUAL REPORTS.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864, 8vo., 13 pp. Out of print.

THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1865. Trenton, 1866, 8vo., 12 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, on the Geological Survey of New Jersey, for the year 1866. Trenton, 1867, 8vo., 28 pp. Out of print.

REPORT OF THE STATE GEOLOGIST, Prof. Geo. H. Cook, for the year of 1867. Trenton, 1868, 8vo., 28 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1869. Trenton 1870, 8vo., 57 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1870. New Brunswick, 1871, 8vo., 75 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1871. New Brunswick, 1872, 8vo., 46 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1872. Trenton, 1872, 8vo., 44 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1873. Trenton, 1874, 8vo., 128 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1874. Trenton, 1874, 8vo., 115 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1875. Trenton, 1875, 8vo., 41 pp., with map. Out of print.

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ANNUAL REPORT of the State Geologist of New Jersey for 1877. Trenton, 1877, 8vo., 55 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1878. Trenton, 1878, 8vo., 131 pp., with map. Out of print.

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ANNUAL REPORT of the State Geologist of New Jersey for 1880. Trenton, 1880, 8 vo., 220 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1881. Trenton, 1881, 8vo., 87+107+xiv. pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1882. Camden, 1882, 8vo., 191 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1883. Camden, 1883, 8vo., 188 pp. (Price, 50 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1884. Trenton, 1884, 8vo., 168 pp., with maps. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton, 1885, 8vo., 228 pp., with maps. (Postage, 9 cents.)

Annual Report of the State Geologist of New Jersey for 1886. **Trenton,** 1887, 8 vo., 254 pp., with maps. (Postage, 9 cents.)

Annual Report of the State Geologist of New Jersey for 1887. **Trenton,** 1887, 8vo., 45 pp., with maps. (Postage, 5 cents.)

Annual Report of the State Geologist of New Jersey for 1888. **Camden,** 1889, 8vo., 87 pp., with map. (Postage, 5 cents.)

Annual Report of the State Geologist of New Jersey for 1889. **Camden,** 1889, 8vo., 112 pp. (Postage, 6 cents.)

Annual Report of the State Geologist of New Jersey for 1890. **Trenton,** 1891, 8vo., 305 pp., with maps. (Postage, 10 cents.)

Annual Report of the State Geologist of New Jersey for 1891. Trenton, 1892, 8vo., xii+270 pp., with maps. Out of print.

Annual Report of the State Geologist of New Jersey for 1892. Trenton, 1893, 8vo., x+368 pp., with maps. (Price, $1.55.)

Annual Report of the State Geologist of New Jersey for 1893. **Trenton,** 1894, 8vo., x+452 pp., with maps. (Postage, 18 cents.)

Annual Report of the State Geologist of New Jersey for 1894. **Trenton,** 1895, 8vo., x+304 pp., with geological map. (Postage, 11 cents.)

Annual Report of the State Geologist of New Jersey for 1895. **Trenton,** 1896, 8vo., xl+198 pp., with geological map. (Postage, 8 cents.)

Annual Report of the State Geologist of New Jersey for 1896. **Trenton,** 1897, 8vo., xxviii+377 pp., with map of Hackensack meadows. (Postage, 15 cents.)

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Annual Report of the State Geologist for 1898. Trenton, 1899, **8vo.,** xxxii+244 pp., with Appendix, 102 pp. (Postage, 14 cents.)

Annual Report of the State Geologist for 1899 and Report on Forests. Trenton, 1900, 2 vols., 8vo., Annual Report, xliii+192 pp. Forests, xvi+327 pp., with seven maps in a roll. (Postage, 8 and 22 cents.)

Annual Report of the State Geologist for 1900. Trenton, 1901, 8vo., xl+231 pp. (Postage, 10 cents.)

Annual Report of the State Geologist for 1901. Trenton, 1902. 8vo., xxviii+178 pp., with one map in pocket. (Postage, 10 cents.)

Annual Report of the State Geologist for 1902. Trenton, 1903, 8vo., viii+155 pp. (Postage, 6 cents.)

Annual Report of the State Geologist for 1903. Trenton, 1904. 8vo., xxxvi+132 pp., with two maps in pocket. (Price, 40 cents.)

Annual Report of the State Geologist for 1904. Trenton, 1905, 8vo., x+317 pp. (Postage, 12 cents.)

Annual Report of the State Geologist for 1905. Trenton, 1906, 8vo., x+338 pp., with three maps in a pocket. (Price, 55 cents.)

Annual Report of the State Geologist for 1906. Trenton, 1907, 8vo., vii+192 pp. (Postage, 10 cents.)

Annual Report of the State Geologist for 1907. Trenton, 1908, 8vo., ix+192 pp. (Postage, 12 cents.)

Annual Report of the State Geologist for 1908. Trenton, 1909, 8vo., xi+159 pp. (Postage, 8 cents.)

Annual Report of the State Geologist for 1909. Trenton, 1910, 8vo., vii+123 pp. (Postage, 6 cents.)

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GEOLOGICAL SURVEY OF NEW JERSEY

Henry B. Kümmel, State Geologist

BULLETIN 2

A Report on the Approximate Cost

OF A

Canal between Bay Head and the Shrewsbury River

BY

HENRY B. KÜMMEL

State Geologist

To the One Hundred and Thirty-fifth Legislature of the State of New Jersey

In accordance with a Concurrent Resolution passed by the Legislature, April 6, 1910

TRENTON, N. J.
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1911.

Report on the Approximate Cost of a Canal Between Bay Head and the Shrewsbury River.

BY HENRY B. KÜMMEL, STATE GEOLOGIST.

To the Senate and House of Assembly of the One Hundred and Thirty-fifth Legislature of the State of New Jersey:

I have the honor to submit a report made in accordance with the following concurrent resolution passed by the Legislature, April 6th, 1910:

"WHEREAS, The construction of the Inland Waterway along the New Jersey Coast has already shown in a marked degree the advisability of such an improvement, and

"WHEREAS, There is a general demand that the same be continued by means of a canal from Bay Head, in Ocean County, to the Shrewsbury River in Monmouth County; therefore, be it

"*Resolved,* By the House of Assembly (the Senate concurring), That the State Geologist be directed, from such data as may be in his possession, to ascertain the approximate cost of the construction of a sea-level canal, with minimum depth of six feet and minimum width at the water level of sixty feet, between Bay Head and the Shrewsbury River; and to report at the next session of the Legislature.

"*Resolved,* That the Governor be authorized to appoint two competent residents of the State, who shall estimate the value of the real estate necessary to be taken for the line of such canal, their estimate thereon to be incorporated in the report of the State Geologist."

The above resolution did not carry with it any appropriation of money, nor did it direct or authorize any survey of a canal route. So far as the State Geologist is concerned it directed only the preparation of an estimate of the *approximate* cost, prepared from data already in possession of the Survey. These data consisted of published topographic maps on a scale of 2,000 feet per inch, with contour intervals of 10 feet, manuscript geological

maps of the rock formations, and well-borings showing strata. There was also a detailed report of the cost of a canal for a part of the route, *i. e.*, from Bay Head to Manasquan Inlet, made in 1903 by C. C. Vermeule, under the direction of the State Geologist, in accordance with an act of the Legislature of that year.

The report which I herewith submit has been prepared from the above data and under the conditions imposed by the resolutions cited. The profile of the proposed route (Fig. 1) has been drawn from the topographical map as accurately as possible, and the amount of excavation carefully computed on the basis of that profile. Mr. C. C. Vermeule has kindly made for me the estimates of the cost of bridges, and other engineers and contractors have made suggestions as to the probable unit cost of excavation. Messrs. R. W. Herbert, of Monmouth County, and A. O. S. Havens, of Ocean County, appointed by the Governor under authority of the resolution, made the appraisal of the right of way. The estimate of cost, while only approximate, is probably as accurate as can be had without a detailed survey of the route and bids for construction.

THE ROUTE.

Location.—Several factors were kept in mind in selecting the route. It was necessary to avoid, so far as possible, all built-up sections of country, and yet if the canal is to serve the shore communities the route must not be far removed from them. A straight route would be the shortest, and from this point of view alone the cheapest, but on the other hand since the canal must be a sea-level canal, the *lowest* route, other things equal, would be the best. The route finally determined upon is the result of compromise between these conflicting factors. It is not the shortest, nor the lowest. It does not altogether avoid built-up sections; it of necessity crosses several lines of railroad and in some places it is some distance from the shore communities. All thing considered, however, it is probably the best route that can be found, since it utilizes, so far as possible, all existing waterways. Its exact location is shown upon the accompanying map. (Plate I.)

Bay Head to Manasquan River.—The route from Bay Head to Manasquan Inlet follows the survey for a tide waterway made in 1903[1]. It "begins a little north of the present railroad bridge over the outlet of Twilight Lake at Bay Head and follows up said outlet and through Twilight Lake. Thence crossing Osborn Avenue and Sea Avenue, it skirts the easterly edge of Maxon's Pond, after which it follows the line of Baltimore Avenue through Point Pleasant. * * * After reaching Central Avenue, the canal curves eastward through Cooks Pond and follows the outlet of Cooks Pond to Manasquan Inlet." The route is quite direct, following the existing water courses and cutting through Bay Head and Point Pleasant in such manner as to do the least possible injury to property.

Manasquan Inlet to Deal Lake.—From the inlet it lies up and across Manasquan River towards Brielle and thence through the salt meadows and along Newberry Lake south of the State Encampment. Passing westward from Newberry Lake along a swampy depression the route turns north just after crossing Broad Street, Manasquan, which it nearly parallels to the stream feeding Wreck Pond. Following up this stream almost to Old Mill, it turns north up a side ravine, keeping on the low ground east of Wall road, to which it lies parallel, as far as Heroys Pond on the south shore of Shark River.

The proposed canal would enter Shark River at Heroys Pond on the south side and leave on the north shore along a short ravine at Neptune avenue, Ocean Grove Heights. Hence it curves slightly to the northeast for a few hundred yards, following the line of a small brook, thence north between Bennett and Stokes avenues, Ocean Grove Heights, to the south arm of Deal Lake near the Asbury Park standpipe. Here the route by following first the south arm and then the north arm of Deal Lake makes a detour to the east and takes advantage of a waterway which will need but comparatively little dredging to give the required depth. Two railroad bridges will be avoided by cutting through the narrow neck of land at Interlaken station. From the north end of Deal Lake at Beechwood Avenue the route follows up a

[1] Annual Report of the State Geologist for 1903, pp. 1–15.

ravine through the golf links at Deal and continues in a slightly sinuous course northward about midway between Whale Pond road on the west and Locust Avenue on the east. It passes slightly west of the triangle of roads at West Long Branch and then curves eastward across the Monmouth road to a swampy depression which it follows past the north end of the Long Branch Cemetery to the head of Pleasure Bay at Myrtle Avenue. In order to secure the necessary depth of water, some dredging will have to be done along Pleasure Bay to a point about half a mile north of the Pleasure Bay drawbridge. The entire length of the route as thus laid out is 21.76 miles. Of this distance 9.47 miles are along present water routes which vary in depth from 1 to 7 feet, the maximum needed, and which will have to be deepened accordingly. The balance is through upland with a maximum elevation of 58 feet above sea level or 65 feet above the bottom of the canal as proposed. From Bay Head to the head of Newberry Lake at Sea Girt the maximum elevation is only a few feet above sea level and much of the route is along existing waterways. From Newberry Lake to Shark River the maximum elevation is 35 feet A. T. and for more than two miles the elevation is 20 feet or more above sea level. Between Shark River and Deal Lake the maximum height is 30 feet A. T. and for 1 1/3 miles over 20 feet A. T. North of Deal Lake heights of 55 to 60 feet are twice reached and for 3 miles the elevation is over 20 feet, making in all about 6 1/3 miles in which the excavations will have to be to a depth exceeding 27 feet (Fig. 1).

Dimensions of Canal.—The resolution prescribes a sea-level canal 60 feet wide at the surface, with a minimum depth of 6 feet. A sea-level canal is a necessity, since a sufficient supply of water for a lock canal cannot be obtained from any drainage system in that vicinity. To obtain a depth of 6 feet it is necessary to estimate on a 7-foot cutting. In making the estimates I have figured on a side slope of 1 1/2 horizontal to 1 vertical, which will give a bottom width of 39 feet. This slope continues 3 feet above the water level, where it is interrupted by a bench or shoulder 6 feet wide on each side. Above this bench the slopes continue at the same gradient (1 1/2 to 1) to the top of

the cut. The cross-section of the canal at West Long Branch, where will be the maximum cutting, is shown in Fig. 2. Owing

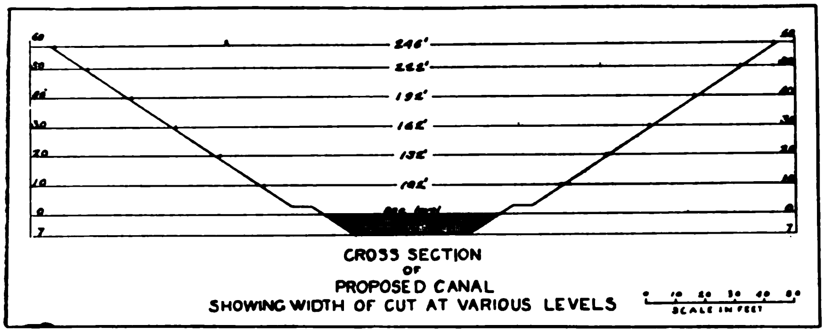

Fig. 2.

to the flaring sides of the cut, it will be noted that each additional foot of elevation increases the width 3 feet and adds greatly to the amount of excavation. At the point of maximum elevation of 58 feet near Oakhurst, the top of the cut will be 246 feet wide. At West Long Branch it will be 237 feet wide, and for 6 1/3 miles of the route it will range between 130 and 246 feet in width.

If, in excavation, quicksand in large quantities should be found, it would probably be necessary to make slopes with much less gradient than 1 1/2 to 1 or resort to protective works of some sort. In either case the cost would be greatly increased by the additional excavation necessary or by the retaining walls.

NATURE OF THE MATERIAL.

No hard rock is known to occur anywhere along the route. Well-borings and other excavations reveal only beds of sand, with locally layers of clay and some greensand marl. So far as may be inferred from all known data, no material may be expected along the route which can not be readily excavated with a steam shovel without blasting.

AMOUNT AND COST OF EXCAVATION.

Method of Computation.—The following method was followed in estimating the amount of excavation necessary. The cross-section of the canal was drawn to scale and the following table compiled, which shows the area of the cross-section of the canal prism and the number of cubic yards of excavation per linear foot for all elevations from 6 feet below sea level to 55 feet above.

TABLE OF AREAS AND VOLUMES.

Elevation in feet above Sea-level.	*Area of Cross-section Sq. ft.*	*Cu. Yds. of Excavation per 1 ft. linear.*
—6,	40½	1.50
—5,	84	3.11$^{1}/_{9}$
—4,	130½	4.83$^{3}/_{9}$
—3,	180	6.66$^{6}/_{9}$
—2,	232½	8.61$^{1}/_{9}$
—1,	288	10.66$^{6}/_{9}$
Sea-level,	346½	12.83$^{3}/_{9}$
1,	408	15.11$^{1}/_{9}$
2,	472½	17.50
3,	540	20.00
4,	622½	23.05$^{5}/_{9}$
5,	708	26.22$^{2}/_{9}$
6,	796½	29.50
7,	888	32.88$^{8}/_{9}$
8,	982½	36.38$^{8}/_{9}$
9,	1,080	40.00
10,	1,180½	43.72$^{2}/_{9}$
11,	1,284	47.55$^{5}/_{9}$
12,	1,390½	51.50
13,	1,500	55.55$^{5}/_{9}$
14,	1,612½	59.72$^{2}/_{9}$
15,	1,728	64.00
16,	1,846½	68.38$^{8}/_{9}$
17,	1,968	72.88$^{8}/_{9}$
18,	2.092½	75.50
19,	2,220	82.22$^{2}/_{9}$
20,	2,350½	87.05$^{5}/_{9}$
21,	2,484	92.00
22,	2,620½	97.05$^{5}/_{9}$
23,	2,760	102.22$^{2}/_{9}$
24,	2,902½	107.50

Elevation in feet above Sea-level.	*Area of Cross-section Sq. ft.*	*Cu. Yds. of Excavation per 1 ft. linear.*
25, ...	3,048	$112.88^{8}/_{9}$
26, ...	3,196½	$118.38^{8}/_{9}$
27, ...	3,348	124.00
28, ...	3,502½	$129.72^{2}/_{9}$
29, ...	3,660	$135.55^{5}/_{9}$
30, ...	3,820½	141.50
31, ...	3,984	$147.55^{5}/_{9}$
32, ...	4,150½	$153.72^{2}/_{9}$
33, ...	4,320	160.00
34, ...	4,492½	$166.38^{8}/_{9}$
35, ...	4,668	$172.88^{8}/_{9}$
36, ...	4,846½	179.50
37, ...	5,028	$186.22^{2}/_{9}$
38, ...	5,212½	$193.05^{5}/_{9}$
39, ...	5,400	200.00
40, ...	5,590½	$207.05^{5}/_{9}$
41, ...	5,784	$214.22^{2}/_{9}$
42, ...	5,980½	221.50
43, ...	6,180	$228.88^{8}/_{9}$
44, ...	6,382½	$236.38^{8}/_{9}$
45, ...	6,588	244.00
46, ...	6,796½	$251.72^{2}/_{9}$
47, ...	7,008	$259.55^{5}/_{9}$
48, ...	7,222½	267.50
49, ...	7,440	$275.81^{5}/_{9}$
50, ...	7,660½	$283.72^{2}/_{9}$
51, ...	7,884	292.00
52, ...	8,110½	$300.38^{8}/_{9}$
53, ...	8,340	$308.88^{8}/_{9}$
54, ...	8,572½	317.50
55, ...	8,808	$326.22^{2}/_{9}$

A profile of the route taken from the topographical maps was then drawn on a scale of 400 feet per inch horizontal and 20 feet per inch vertical. This profile was divided into short sections, the average height of which could be accurately determined from the drawings. The cubic contents of each prismoid was then calculated by the formula $V = L \times \frac{A + a + 4M}{6}$, in which "V" equals volume, "L" length of the prismoid, "A" the area of the larger cross-section, "a" that of the smaller and "M" the area of a cross-section midway between A and a, *i. e.*, the cross-section corresponding to the average height.

The following table shows by sections the amount of excavation thus computed, except that for the section from Bay Head to Manasquan Inlet the estimate made in 1903 by Mr. Vermeule[1] was taken. It must be borne in mind that these figures, except for the short section between Bay Head and Manasquan Inlet, are not based upon detailed instrumental surveys, but from data taken from the topographic map. The latter is as accurate as its scale warrants, and these figures are approximately correct. While an instrumental survey would unquestionably result in somewhat different figures, it is doubtful whether such differences would amount to 8 or 10 per cent. These figures will be considerably increased if by reason of quicksand it is necessary to adopt side slopes with less gradient than 1½ to 1.

TABLE OF DISTANCES AND AMOUNTS OF EXCAVATION.

	Distance Feet.	*Cubic Yards of Excavation.*
Bay Head to Manasquan River, ...	13,600	727,411
South shore of Manasquan River to upper end of Newberry Lake, ...	11,800	92,473
North end of Newberry Lake to Shark River, ...	20,900	1,618,590
Shark River, ...	8,260	35,767
Shark River to Deal Lake, ...	10,740	912,037
Deal Lake, ...	13,000	55,718
Deal Lake to Pleasure Bay, ...	27,200	3,529,756
Pleasure Bay, ...	9,500	57,043
	115,000	7,028,795

METHODS OF WORK.

Excavation.—Suction dredges could probably be employed for those portions of the route between Bay Head and Newberry Lake, across Shark River, Deal Lake and Pleasure Bay. The amount of excavation which could probably be handled in this manner is estimated at 968,412 cubic yards. For the balance of the material it would probably be necessary to use steam shovels.

Disposal of Material.—The cheapest method of disposing of

[1] Annual Report of the State Geologist of N. J. for 1903, p. 11.

the material is to place it upon the land adjoining the canal, but this method has very serious disadvantages. For the most part the route lies through high, well-drained country. Low tidal marshes on which it might be spread to their great improvement are absent except along a very limited portion of the route. For at least eleven miles the route is through good farms or across suburban property which is rapidly increasing in value and much of which will in a few years be built up or included in the large country homes of the wealthy. Some of it is now valued by the appraisers at $1,000 per acre. It is in those sections of the route where the land has the greatest elevation, where the cutting is deepest, where the excavation is greatest, and where the amount of material is largest, that the land has the most value and the plan of placing it along the canal will be most objectionable because of the enormous size of the embankments and their inherent ugliness.

In order to comprehend better what is involved in placing the material along side the cut, it will be well to take a few specific instances. At West Long Branch, where the canal trench would have a top width of 222 feet and a depth of 62 feet, it would be bordered by two embankments each 200 feet wide at the base and 27 2/3 feet high, if all the excavated material be dumped on the banks. South of Oakhurst, where the maximum cutting occurs, and where the canal trench would be 246 feet wide at the top and 65 feet deep, there would need to be two enbankments each 200 feet wide and 31 feet high. For most of the distance between Deal Lake and Shark River the embankments would be 8 1/3 feet high if 200 feet wide each and nearly 24 feet high if only 100 feet wide at the base. South of Shark River for considerable stretches they would be 10 1/3 feet high and 200 feet wide, with a maximum height of 12 feet where the cutting was deepest. For more than 6 miles of the entire route the embankments, if 200 feet wide, would range in height from 6 to 31 feet.

To dispose of the material in this manner it would be necessary to purchase land in addition to that needed for the right of way or to acquire the right to fill. For those portions of the route bordered by swampy areas it is possible that the owners would be willing to have their land filled without cost, or,

what is much less likely, might even pay a small sum for the privilege. The maximum distance so covered will probably not exceed 43,160 feet, or about 8 miles. For upwards of 11 miles (58,840 feet) land would certainly have to be purchased along the right of way. If we assume that adjoining those portions of the route with a less elevation than 20 feet the material could be piled in two 100-foot embankments with maximum height of between 18 and 19 feet; adjoining those with elevation 20 to 35 feet, in embankments 150 feet wide with maximum height of 20 feet; and for the remaining portions in embankments 200 feet wide with maximum height of 31 feet, there would be needed in addition to the right of way for the canal itself—

For 25,640 linear feet, a strip 200 feet wide;

For 24,500 linear feet, a strip 300 feet wide;

For 8,700 linear feet, a strip 400 feet wide;

or 366 acres in all.

There are serious objections from the esthetic standpoint to disposing of the material in huge piles along the route. Much of the region traversed is one rapidly being developed for summer homes. To cross it with a trench from 100 to 250 feet wide and from 10 to 65 feet deep and bordered on both banks by piles of clay, sand and gravel from 100 to 200 feet wide and 10 to 31 feet high is certainly a proposition against which much can be said from the standpoint of scenic beauty. And in a region of this character this factor in its future development cannot be ignored.

Various other methods of disposing of the material have been considered, but they all involve enormous expense for hauling, and if the material is dumped on land, for the cost of the land. If, on the contrary, the material is towed to sea and dumped, there will be very high costs for towing. It has been suggested that it will be possible to sell large quantities of the dirt for filling purposes. This may be true, particularly if the work be done piecemeal and its accomplishment be distributed over a considerable period so as not to glut the market. In making up an estimate of this character, however, the possibility of selling or even giving away the material seems so uncertain that it is not safe to include it and make any allowance in dollars and cents for it. To mention it as a possibility is all that can be done in this connection.

Cost of Excavating and Disposing of Material.—For the portion of the route from Bay Head to Manasquan Inlet, for which an estimate for a canal has already been made,[1] no new figures were compiled. The total cost of that portion of the route as previously determined, is added to the final estimate as given on page 19.

For the balance of the route, that is from Manasquan Inlet to Shrewsbury River, the cost of excavation will depend chiefly upon the plan adopted for disposing of the material. In making this estimate of cost it is assumed that for the following portions of the route and volumes of material a suction dredge can be used and the material pumped on the adjacent lowland, at the cost indicated below.

	Distance in Feet.	*Volume in Cu. Yds.*	*Cost Per Unit.*	*Total Cost.*
Manasquan Inlet to upper end of Newberry Lake, ...	11,800	92,473	16c.	$14,795 68
Shark River, ...	8,260	35,767	22c.	7,858 74
Deal Lake, ...	13,000	55,718	20c.	11,143 60
Pleasure Bay, ...	9,500	57,043	19c.	12,238 17
	42,560	241,001		$46,046 19

If on the balance of the route a steam shovel and elevators be used, the material being placed along the canal in two embankments as outlined on pages 11 and 12, the cost of excavation is estimated as follows:

6,060,383 cubic yards @ 16c., ...	=	$969,661 28
79.5 acres of land @ $1,000, ...	=	79,500 00
286.5 acres of land @ $750, ...	=	214,875 00
		$1,264,036 28

The above unit price of 16 cents per cubic yard includes contractor's profit and cost of plant. It is based on results attained in digging, elevating, and piling a somewhat heavy clay along the Chicago drainage canal. It is probably low and could be attained only if the work were done under large contracts and

[1] C. C. Vermeule, Annual Report of the State Geologist for 1903.

with efficient superintendence. Much railroad work, including excavation of loose sand and gravel, haulage a few hundred feet and dumping in making an embankment, costs much more than this figure. It is very doubtful whether with the limited appropriations which are usually made for State work and the small piecemeal contracts resulting therefrom, this unit price can be obtained in practice. Any increase in the unit price for excavation will, of course, largely increase the final cost. The value of the land is based on the appraisal made by Messrs. Herbert and Havens.

If instead of piling the material along the banks, it be hauled to waste places we may estimate the cost as follows:

Excavation and loading on cars,	4½ cents
Hauling and dumping—Average haul of 2 miles,	13½ cents
Spreading,	1½ cents
Contractor's profit,	3 cents
	22½ cents

6,060,383 cu. yds. @ 22½ cents = $1,363,585.17.

Assuming that it will be possible to dump an average of 9 feet or 14,520 cubic yards per acre, 417 acres of waste land will be needed.

It is doubtful whether suitable dumping grounds so located that the average railroad haul will not exceed 2 miles can be obtained for less than $100 per acre. If so, the cost of land for this purpose will be $41,700. If suitable lands cannot be obtained within the specified distance a longer haul may be necessary. With the average haul increased to 3 miles, the unit price would be increased from 22½ to 29 cents with a corresponding increase for excavation from $1,363,586 to $1,758,381. In view of the great increase in cost due to long hauls it would be manifestly cheaper to pay high rates for dumping grounds near the canal than to attempt to utilize cheap or possibly free dumping grounds with attendant long hauls.

The cost of towing and dumping the material at sea is so excessive, amounting to 25 cents or more per cubic yard, for a 5 mile tow (which is the average needed under the most favorable

conditions), in addition to the cost of digging and hauling to a dock, that it does not seem worth while to consider this manner of disposal.

BRIDGES.

According to the latest maps the route is crossed by 52 streets and roads and by 6 lines of railroad. A few of the former have very little existence except on paper, but by far the greater number are frequently traveled and many of them are improved stone or gravel roads over which there is constant traffic. Only one wagon road is now provided with a drawbridge, and none of the railroad crossings now have draws. It is assumed that in the event of the canal construction, it will be possible to close a number of the least important roads so as to reduce as far as possible the number of bridges necessary to construct and maintain. In making this assumption the question of damages in closing established roads must not be overlooked, but at the most they would probably be less than the cost of a corresponding number of bridges. No estimate can be made as to the amount of such damages, but their possibility must not be overlooked. It is assumed that for the portion of the canal between Pleasure Bay and Manasquan Inlet there will be at least 31 bridges, including 4 railroad bridges. These cross at all elevations up to 55 feet and with their approaches vary in length from 80 to nearly 300 feet. Two estimates of their cost have been made. One provides for overhead clearance of 40 feet and 30-foot draws where this cannot be obtained; the other for 20-foot clearance with draws for lower bridges. The latter plan will be the more economical in the long run, although the first cost is higher, but its adoption will restrict the use of the canal to boats needing less than 20 feet head room.

Bridges with Forty-Foot Clearance.—For bridges having a height of 45 to 55 feet above sea level, the type selected is a steel viaduct consisting of five 40-foot spans on concrete foundations. The roadway is carried by two steel plate girders with transverse 12" I-beams, spaced 8 feet apart, the floor being made up with buckle plates on which is laid a macadam roadway, making a substantial and permanent structure. Bridges of the above

height have no draw. All bridges of a less height are provided with drawbridges of the rolling lift or bascule type. Also the spans are reduced to 30 feet. At each side of the draw span there is a concrete pier the full height of the bridge, beyond which is a steel viaduct on concrete footings extending out to within ten or twelve feet of the top of the cut. In all cases the ends of the viaduct rest upon concrete abutments with wing walls.

It will be noted that by this plan there will be 40 feet clearance above sea level and 29 out of 31 bridges will require a draw. The estimated cost on the foregoing plan is as follows:

Branchport Ave.,	Draw,	$9,000
Long Branch Railroad,	"	12,000
Myrtle Ave.,	"	7,100
New Jersey Southern Railroad,	"	7,600
Oceanport Ave.,	"	7,100
Broadway,	"	7,100
West Long Branch,	No Draw,	10,600
Poplar Ave.,	" "	10,600
Kennedy Road,	Draw,	16,000
Crosby Ave.,	"	16,000
Beechwood Ave.,	"	11,900
Deal Beach Ave.,	"	7,100
Interlaken,	"	7,100
Sunset Ave.,	"	7,100
Ridge Ave.,	"	7,100
Asbury Ave.,	"	7,100
Monroe Ave.,	"	11,900
Springwood Ave.,	"	11,900
Corliss Ave.,	"	11,900
Seventh Ave.,	"	11,900
Sylvania Ave.,	"	16,000
Shark River Road,	"	7,100
New Bedford Ave.,	"	11,900
Bailey's Corner Road,	"	14,000
Ocean Ave.,	"	7,100
Blansingburgh Road,	"	11,900
Broad Street, Manasquan,	"	7,100
Freehold and Jamesburg Railroad,	"	12,000
Long Branch Railroad,	"	12,000
Main Street, Manasquan,	"	7,100
Brielle Road,	"	7,100
		$311,400
Contingencies 10%,		31,140
Total,		$342,540

Bridges with Twenty-Foot Clearance.—The second estimate is made up upon the assumption that the overhead clearance is to be limited to twenty feet above sea level and that in all cases where this can be secured, draws will be eliminated. This plan will not be cheaper in first cost for the reason that if such a limitation be adopted it immediately becomes expedient to raise as many of the bridges as possible so as to give a clearance of 20 feet, thereby saving the expense of operation and maintenance of drawbridges. This is especially important at the four railroad crossings, not only on account of saving in operating expenses, but more particularly on account of the avoidance of possible accident at open draws upon these railroads, all of which carry a large passenger traffic. To carry out this plan will require raising the grade of the railroads and the appoaches at several of the highway bridges. As will be seen from the following estimate, the drawbridges are reduced to 10 instead of 29 shown in the previous estimate. The estimate of cost is as follows:

Branchport Ave.,	Draw,	$9,000
Long Branch Railroad, new bridge and raising of grade,	No Draw,	42,000
Myrtle Ave.,	Draw,	7,100
New Jersey Southern Railroad, new bridge and raising of grade,	No Draw,	15,600
Oceanport Ave.,	Draw,	7,100
Broadway,	"	7,100
West Long Branch,	No Draw,	10,600
Poplar Ave.,	" "	10,600
Kennedy Road,	" "	13,500
Crosby Ave.,	" "	13,500
Beechwood Ave.,	" "	14,500
Deal Beach Ave.,	Draw,	7,100
Interlaken,	"	7,100
Sunset Ave.,	"	7,100
Ridge Ave.,	No Draw,	12,500
Asbury Ave.,	" "	12,500
Monroe Ave.,	" "	9,500
Springwood Ave.,	" "	9,500
Corliss Ave.,	" "	9,500
Seventh Ave.,	" "	9,500
Sylvania Ave.,	" "	9,500
Shark River Road,	Draw,	7,100
New Bedford Ave.,	No Draw,	6,700
Bailey's Corner Road,	" "	6,700
Ocean Ave.,	" "	9,000

Blansingburgh Road, ...	No Draw,	$6,700
Broad Street, Manasquan, ...	" "	9,000
Freehold and Jamesburg Railroad and raising grade, ...	" "	19,000
New York and Long Branch Railroad and raising grade, ..	" "	24,000
Main Street, Manasquan, ...	Draw,	7,100
Brielle Road, ...	"	7,100
		$346,800
Contingencies 10%, ...		34,680
Total, ...		$381,480

It will be observed that the second plan costs $38,940 more than the first, but it eliminates 19 drawbridges of which 4 are railroad bridges. If we estimate that each railroad draw requires the attendance of two men at $50 per month and that each highway draw requires the attendance of one man at $50 per month, we have a total saving in charges of $1,150 per month or $13,800 yearly. We may also estimate the supplies, repairs and replacement account at $1,000 annually for each railroad drawbridge and $600 annually for each highway drawbridge, making $13,000 annually for all of the bridges eliminated, which, added to the wages account saved, makes a total saving in operation of $26,800 yearly. It is, therefore, apparent that the second plan is decidedly the more economical. The choice of plan must be determined by weighing the saving in annual operating expenses and any danger of accident against the decreased availability of a waterway with only 20 feet head room as compared with one with 40 feet head room under the bridges.

RIGHT OF WAY.

In estimating the width of the right of way necessary, it has been assumed that a strip at least 50 feet wider than the cut must be obtained, thus giving 25 feet leeway on either bank. This is exclusive of any ground necessary for dumping the material, if it should be determined to place it along the canal. As noted above, the appraised value of the right of way was made by Messrs. R. W. Herbert and A. O. S. Havens. Their report to Governor Fort is herewith presented:

"*To Hon. John Franklin Fort,*
Governor of New Jersey:

We, the undersigned, having been appointed by you commissioners to appraise the value of the property needed for the proposed Inland Waterway from Bay Head, in Ocean County, to Pleasure Bay, in Monmouth County, according to maps prepared by Henry B. Kümmel, State Geologist, beg to report that the amount thought necessary to secure the right-of-way for said Waterway is

ONE HUNDRED FIFTY SIX THOUSAND DOLLARS.

We found all people consulted very enthusiastic over the proposition, with an inclination to make concessions in prices and in some instances donations of right-of-way.

Most respectfully submitted,

RICHARD W. HERBERT,
A. O. S. HAVENS,
Appraisers.

December the sixteenth,
A. D. Nineteen Hundred and Ten.

SUMMARY OF COSTS.

For convenience of reference a summary of costs is here presented.

Bay Head to Manasquan Inlet—		
Cost of section from Bay Head to Manasquan Inlet, according to estimates heretofore made, but not including right-of-way, and including one additional railroad bridge,	$148,109	$148,109
Manasquan Inlet to Shrewsbury River—		
Dredging 42,560 linear ft., 241,001 cubic yards, at 16c. to 22c.,	46,046	46,046
Excavating and dumping 6,063,383 cu. yds. including cost of land for dumping and hauling @ 16c. to 29c. per yd., according to plan of disposal adopted,	$1,264,036 to	1,800,081
Thirty-one highway and railroad bridges, according to plan adopted,	342,540 to	381,480
Right-of-way for canal,	156,000	156,000
Net total,	$1,956,731 to	$2,531,716
Administration, engineering, legal and contingencies 10 per cent.,	195,673 to	253,171
	$2,152,404 to	$2,784,887

To the above figures must be added the cost of any retaining walls, rip-rap along the canal, approaches to the canal where it

passes through high ground, additional excavation which may be necessary through the adoption of gentler side slopes and also damages for closing a number of roads now crossing the proposed route. Neither the necessity nor the amount of these additional items can be now determined from any data in my possession and, therefore, no estimate of their probable cost can be made.

In considering the above figures one other condition must be kept in mind. The estimate has been made on the assumption that the entire excavation be covered by one or two large contracts; the same with the bridges. If, however, the policy heretofore followed in the inland waterway dredging of doing the work in small sections by contracts of $75,000 to $100,000, be pursued in this work, not only will the administrative and other overhead charges be greatly increased, but the unit prices obtainable will be considerably in excess of those given above, and the ultimate cost will be much larger.

Allusion has been made to the cost of maintaining drawbridges over the canal. One other probable maintenance charge should be mentioned. For more than 6 miles the canal, if dug, will be bordered by banks more than 20 feet high. So far as known the bulk of the material is sand. The wash from these slopes in wet weather and the wind-blown sand in dry weather will be considerable, and will probably result in no small shoaling of the canal. Periodical dredging will, therefore, be necessary to maintain its depth, but, in default of accurate data on this subject, no estimate of the cost can be made.

Respectfully submitted,

HENRY B. KÜMMEL,
State Geologist.

Trenton, N. J.,
January 30, 1911.

GEOLOGICAL SURVEY OF NEW JERSEY
HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 3.

The Flora of the Raritan Formation

BY

EDWARD W. BERRY

OF THE

JOHNS HOPKINS UNIVERSITY

TRENTON, N. J.
MacCrellish & Quigley, Printers, Opposite Post Office.

1911.

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TRENTON, N. J., MARCH 17, 1911.

The State Printing Board,
Trenton, N. J.

GENTLEMEN—Chapter 46, Laws of 1910, provides that in addition to an annual administrative report, the State Geologist shall prepare or cause to be prepared such scientific reports as are pertinent to the work of his department, and that the State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed such scientific reports.

The Board of Managers of the Survey, on December 6, 1910, adopted the following motion: That the publication of reports on the Plant Remains of the Cretaceous Clay Beds, and on the Fossil Fishes of the Cretaceous and Miocene Formations of South Jersey, already prepared or in process of preparation under the direction of the State Geologist, be recommended for printing to the State Printing Board, as provided in Chapter 46, Laws of 1910.

In accordance with the above, I request that the State Printing Board order printed 1,500 copies each of the two reports above mentioned, 100 to be bound, the balance in stiff covers sewed, as provided in the specifications for printing the Geological Survey reports.

Respectfully submitted,

HENRY B. KÜMMEL,
State Geologist.

STATE OF NEW JERSEY,
OFFICE OF COMPTROLLER OF THE TREASURY.
TRENTON, MARCH 20, 1911.

Henry B. Kümmel, Esq.,
State Geologist,
Trenton, N. J.

DEAR SIR—Your communication of the 17th inst., addressed to the State Printing Board, was laid before the Board at its meeting held on Friday, last, and, on motion, it was ordered that the publications referred to in your letter be printed and bound as requested. The work will be done by MacCrellish & Quigley, who were awarded the contract last fall.

Very respectfully,
E. J. EDWARDS,
Comptroller, as Secretary, State Printing Board.

PART I.

The Raritan Flora.

GENERAL RELATIONS.

I. INTRODUCTION.

The clays of New Jersey constitute the basis of a most important element in the State's mineral wealth and have long furnished the raw material for a variety of industries, and given employment to a large force of labor, both skilled and unskilled. The most conspicuous clay deposits in the State are those known as the Raritan, or Amboy, clays. Very early they attracted the attention of the State Geological Survey, and we find considerable space devoted to them in the Geology of New Jersey, published in 1868, in the Clay Report of 1878, and in the various later reports.

The only comprehensive treatment of the flora of the Raritan formation is that of Prof. Newberry[1], published posthumously in 1896, his active work on it having been stopped by failing health in the fall of 1890. In the interval of twenty-one years which has elapsed, both geology and paleobotany have made prodigious progress in this country, and it is no discredit to the pioneer workers that revision becomes a necessity. One of the imperfections of Prof. Newberry's work, along with that of his colaborers in the field of paleontology, was their neglect in stating the precise localities and horizons from which their specimens were collected. It has been possible to supply some of these deficiencies in frequent visits to the various pits, others remain as Prof. Newberry left them.

Considerable material collected by the U. S. Geological Survey has furnished a number of additions to the flora, for which acknowledgement is gratefully made at this point. All of Prof. Newberry's types are in the museum of the New York Botanical Garden, where they are well arranged and easily accessible. The author's thanks are due Dr. Hollick, the curator of the paleo-

[1] Newberry, The Flora of the Amboy Clays, Mon. U. S. Geol. Survey, Vol. XXVI (1895), 1896.

botanical collections, for free use of this material. The balance of the type material is to be found in the U. S. National Museum, and the writer is under obligations to Dr. Knowlton for the privilege of studying it, as well as for many other favors. Acknowledgement is also gratefully made for the constant interest and encouragement of Dr. Henry B. Kümmel, the State Geologist, who has been keenly cognizant of the importance of a modern treatment of the Paleontology of the State, both palezoological and paleobotanical. The accompanying plates make no pretense at completeness, but aim to show only the more characteristic Raritan species, or forms never before described or figured.

II. HISTORICAL SKETCH.

The Raritan and allied formations have been the subject of numerous contributions to science during the past fifty years, while scattered references to these deposits, which extend back over a century and a half, may be found in the older works.

The Royal Academy of Sciences of Sweden sent the distinguished naturalist, Peter Kalm, who is commemorated in the generic name of our beautiful laurels *(Kalmia)* to America, in 1749, and the results of his travels and investigations were subsequently published in three volumes at Stockholm, and afterward translated into English and French. His was, perhaps, the first contribution to Coastal Plain geology which is worthy of mention. Twenty-eight years later a German naturalist, Johann David Schoepf, visited this area, and in a book published at Erlangen, ten years later, he records many observations of interest. The first geologist to attempt any correlation with Europe was William Maclure, who in various publications covering the period from 1809 to 1817, referred the Coastal Plain deposits collectively to the "Alluvial formation," the fourth of the main divisions of Werner's classification.

Samuel Akerly, in 1820, and James Pierce, in 1823, discussed the "alluvial deposits" in the vicinity of Raritan Bay without, however, having added much that was new.

The first author to recognize even in slight measure the complexity of the Coastal Plain formations was John Finch, an Englishman, and an ardent collector of fossils. He read a paper before the Philadelphia Academy in 1824, at the close of his travels, and on the eve of his departure for England, which was subsequently published.[1] Some years later he published a book on the same subject. He condemns the term "alluvial" and points out that the Coastal Plain deposits of Maclure and others are identical with the newer Secondary and Tertiary formations of Europe. The non-marine Cretaceous he correlates on the

[1] Amer. Jour. Sci. (I), VII: 31–43, 1824.

basis of its contained amber and lignite with the Baltic Tertiar of Europe.

The credit for the first definite recognition of the Cretaceou age of any of the Coastal Plain deposits belongs to Vanuxer and Morton. Together, in 1828, they published a paper in th Journal of the Philadelphia Academy,[1] in which the Coast Plain deposits are classified as follows:

Modern Alluvial.
Ancient Alluvial.
Tertiary.
Secondary { Lignite. / Marl.

Both Vanuxem and Morton published subsequent papers, bu their chief interest, however, centered in the fossil remains of th Marl series, which they correlated with the Lower Chalk, o Ferruginous Sand formation of Europe.

In 1832 Conrad divided the Coastal Plain into six forma tions, i. e.:

Alluvium.
Diluvium.
Gravier Coquillier, of Brong. Crag (mouth of the Po tomac.)
Upper Marine, or Upper Tertiary (Peninsula of Mary land, etc.)
Middle Tertiary, or London Clay and Calcaire grossie (Ft. Washington, Claiborne, etc.)
Lower Tertiary, or Plastic Clay (Bordentown, Whit Hill, N. J.; Cape Sable, Md., etc.)

Lignite, pyrite and amber are mentioned from the Plasti Clay formation. This was the first classification which eve hinted at the true complexity of the Coastal Plain, and fron this time onward the latter has been treated not as a single, or at most, a few formations, but as a long series of deposits o varied composition and age.

In 1835[2] and again in 1842[3] Morton set forth his views o the classification of the Cretaceous, dividing it into an Upper

[1] Jour. Acad. Nat. Sci., Phila., (I) Vol. 6: 59–71, 1828 (1829).
[2] Amer. Jour. Sci. (I) Vol. 28: 276-278, 1835.
[3] Jour. Acad. Nat. Sci. Phila. (I), Vol. 8: 207-227, 1842.

Medial and Lower series, the former of which is now known to be largely Eocene, while the latter included not only part of the present marine Cretaceous, but the Raritan and Magothy formations as well.

During the decade of 1830 to 1840, geological surveys were organized in New York, New Jersey, Delaware and Maryland and these were directed, or taken part in, by William M. Mather, Henry D. Rogers, J. C. Booth, and J. T. Ducatel, respectively. Professor Rogers' first report, published in 1836, and his final report of four years later, recognized the following Cretaceous formations in New Jersey:

Brown Sandstone.
Ferruginous Sand.
Limestone.
Greensand.
Clays and Sand.

The lowermost of these, in a vague manner, corresponds to the Raritan formation of modern authors. Ducatel, in his report for 1837, records the Cretaceous from the eastern shore of Maryland, and Booth, in his report, which was published in 1841, divides the "Upper Secondary" of Delaware into the "Red Clay" and "Greensand" formations. In his first reports (1837 and 1838) Mather mentions the clays and sands of Staten and Long Islands, and he points out their probable equivalency with those "of Cheesequake and Matavan Point, on the New Jersey shore." The earlier New Jersey Survey having come to an end, a considerable interval elapsed during which local geological activity was at a standstill. The second survey was organized under William Kitchell, with George H. Cook as assistant geologist, and in the first report for the year 1854, Cook commenced his series of contributions to the Cretaceous belt of New Jersey, which continued year by year until his death, in 1889, after a service as State Geologist extending over twenty-five years.

Considerable space is devoted to the Woodbridge and South Amboy clays in Professor Cook's Geology of New Jersey, published in 1868. His divisions were as follows:

Plastic Clay $\begin{cases}\text{Lignite.}\\ \text{Potters' Clay.}\\ \text{Lignite.}\end{cases}$

The first fossil plant from the Raritan to receive scientific description was the *Podozamites,* described by Conrad from the banks of South River, in 1869. Fossil plants had been described and figured from Marthas Vineyard by Hitchcock as long ago as 1841 (Final Rept. Geol. of Mass., Vol. 2, 1841), and various authors had mentioned vegetable remains in Maryland and Virginia and other southern states.

These leaf impressions in the Raritan Clays early attracted the attention of Professor Cook, and large collections were made. Unfortunately, like the leaves in so many of the unlithified plant beds of the Coastal Plain, those of the Raritan are usually represented by a more or less thick sheet of carbonaceous matter, which, when dry, soon shrinks, cracking and weathering away and leaving faint and almost worthless impressions behind. This has always been an obstacle to their proper study, as it was in the study of Professor Cook's collections which were submitted to Lesquereux. Professor Lesquereux prepared a list of species, which was published in the Clay Report of 1878, but because of this poorness of preservation, little reliance can be placed upon his determinations. Several of these species have never since been observed, and they are ignored altogether in the systematic part of the present report.

The following is a list of Lesquereux's determinations:

Andromeda.
Araliopsis.
Cinnamomum Heerii Lx.
Daphnophyllum?
(Dryophyllum.)
Glyptostrobus gracillimus Lx.[1]=Widdringtonites
Reichii of this report.
Laurus sp.
Leaves of a peculiar new kind of fern.
Magnolia alternata Heer.[1]
Magnolia Capellinii Heer.
Myrica, or *Lomatia.*

Persea nebrascensis Lx.
Platanus Heerii Lx.
Proteoides daphnogenoides Heer[1]=Ficus daphnogenoides of this report.
Proteoides, undeterminable.
Quercus, dentate leaves.
Rootlets.
Rootlets of *Equisetum*.
Salix proteæfolia Lesq[1]=Salix Lesquereuxi of this report.
Sassafras (Araliopsis.)
Seed of *Conifer*.
Sequoia condita Lx.
Sequoia Reichenbachi Heer.[1]
Sequoia rigida Heer.
Sequoia Smithsiana Heer (sic.)
Sequoia subulata Heer.
A *Sequoia* with thick leaves.
Sterculia sp.
Sterculia, undetermined species.

This list was published in the special volume of the Clays of New Jersey, by Cook and Smock. The Raritan area was treated at length in this work, and the deposits were classified substantially as they are at the present time. Following is Professor Cook's somewhat generalized section of 1878:[2]

Stoneware clay,	30 ft.
Sand and sandy clay,	50 ft.
South Amboy fire clay,	20 ft.
Sandy clay with leaf-impressions,	3 ft.
Sand and "kaolin,"	10 ft.
"Feldspar,"	5 ft.
Micaceous sand,	20 ft.
Laminated clay and sand.	30 ft.
Pipe clay,	10 ft.
Sandy clay with leaf impressions,	5 ft.
Woodbridge fire clay,	20 ft.
Sand,	15 ft.
Raritan fire clay,	15 ft.
Sandy lignitic clay,	4 ft.
Potters clay,	20 ft.

[1] Known members of the Raritan flora.
[2] Cook and Smock, Rept. on Clays, 1878, p. 34.

The next author to take up a study of the Raritan flora was Professor Newberry, whose work extended over a number of years, during which several minor papers were published, and which culminated in his Flora of the Amboy Clays, issued in 1896, as Monograph XXVI. of the U. S. Geological Survey, after the death of its eminent author. In this work, 156 species were described. These included, however, species outside the Raritan formation and younger in age, in one instance even including a Pleistocene species from the Fish House Clays. Then, too, Professor Newberry, through failing health, was unable to complete his work, and the posthumous monograph too often lacks information regarding the localities from which the various forms were collected.

The name Raritan, as a formational name, was proposed by Prof. W. B. Clark, in 1893, to replace Professor Cook's lithological term, Plastic Clays, although the boundaries of the formation remained practically the same. The former author at one time considered the Raritan the uppermost formation of the Potomac group, the older formations of which are so largely developed in Maryland and to the southward. In this he was followed by Prof. L. F. Ward and others, but the Potomac group has subsequently been restricted to include the Lower Cretaceous Patuxent, Arundel and Patapsco formations.

In 1904 the present State Geologist, Henry B. Kümmel, in collaboration with Heinrich Ries and G. N. Knapp, published a very complete report on the Clays and Clay Industry of New Jersey, in which the Raritan is fully treated. In this report the Raritan is divided into the following members in Middlesex County:[1]

Amboy stoneware clay,	30 ft.
Sand bed No. 3 (at times argillaceous and lignitic),	50 ft.
South Amboy fire clay,	25 ft.
Sand bed No. 2,	45 ft.
Woodbridge clay,	30 to 60 ft.
Sand bed No. 1,	35 ft.
Raritan clay,	35 ft.

[1] Final Rept. State Geol., Vol. VI, 1904, p. 166.

More recently the fauna of these deposits was described by Stuart Weller, in his volume on Cretaceous Paleontology.

The lower boundary of the Raritan has never been questioned, but its upper limits have been more uncertain and have called forth considerable discussion, the present writer having indicated this upper boundary in 1905.

III. THE RARITAN FORMATION.

INTRODUCTORY.

New Jersey has been divided into four physiographic zones. The oldest of these, known as *The Highlands,* dates from remote geological time, its constituent rocks consisting for the most part of highly metamorphosed crystalline schists. This zone occupies a broad belt across the northern central portion of the State, and includes the eastern part of Sussex and Warren counties, the northern part of Passaic County, most of Morris County, and the northern part of Hunterdon County. It corresponds in age with the Piedmont Plateau of the states to the southward, and is represented by the basal part of the section in Figure 1. Following the emergence of this belt of land in early geological times, sediments were laid down along its western borders, and it is these Paleozoic sediments, since much folded, which today make up the *Appalachian zone,* comprising the Kittatinny valley and mountain of the northwestern portion of the State, in Sussex and Warren counties.

The third and next younger zone, which is known as the *Piedmont Plain,* was laid down on the eastern flanks of the Highland area at a much later date. Topographically, it corresponds to the Piedmont Plateau region of the states to the southward, but consists, in New Jersey, of much younger rocks of late Triassic age, and includes roughly all or a part of Bergen, Passaic, Essex, Union, Somerset, Middlesex, Hunterdon, and Mercer counties.

The fourth and youngest zone, known as the *Coastal Plain,* includes the remainder of the State and extends from the present coast inland to the exposed area of the Triassic rocks. It is made up of unconsolidated and undisturbed sediments, ranging in age from Cretaceous to Recent.

A glance at the geological column shown in Figure 1, which is drawn approximately to scale, will show the relative position

ERAS	PERIODS	SECTION	MATERIALS	BIOTIC CHARACTERS
Cenozoic	Quaternary		Glacial products	Appearance of man
	Tertiary		Sands and Clays	Rise of Mammals
Mesozoic	Cretaceous		Sands, Clays and Glauconite	Rise of Angiosperms
	Jurassic	Absent		Age of Cycads and Reptiles
	Triassic		Sandstones and Shales Extrusive and Intrusive lava flows	Age of Conifers
Paleozoic	Permian	Absent		Pteridophytes and Primitive Seed-plants of the Coal
	Carboniferous	Absent		
	Devonian		Sandstones, Shales, Limestones and Conglomerates	Ancestors of the Coal Flora
	Silurian		Limestones, Shales and Sandstones	The First Land Plants
	Ordovician		Limestones and Slates	Marine Life
	Cambrian		Quartzites and Limestones	Marine Life
Proterozoic	Unknown but very great thickness of rocks			Indications of Organic Life
Archæozoic	embracing an enormous lapse of time			

Fig 1.—Diagram Showing the sequence and relative thickness of the Geological divisions in New Jersey.

of the strata of the Raritan formation, and could the duration of geological time which has gone before it be expressed in years, we would obtain a still more vivid picture of the comparative youth of the Cretaceous period, even though this is offset with the reflection that the Cretaceous is removed several million years from the present, and the plants described in the following pages antedate all of the higher animals, and were the

contemporaries of the huge and uncouth reptilia, the Dinosaurs, Mososaurs, etc., which have long since vanished.

In leading up to a consideration of the Raritan formation, we need not go back farther than the close of the Triassic period. After the deposition of these Triassic sandstones and shales with their accompanying intrusions and extrusions of igneous rock, the whole region was elevated (the post-Triassic uplift). The rising land was immediately subjected to erosion, which went on during the whole of the Jurassic and Lower Cretaceous periods until at length the surface was essentially a vast plain, the Schooley peneplain, as it is called. At some time about the close of the Lower Cretaceous there was a subsidence, or warping, of this Schooley plain, and deposition along its eastern flank succeeded erosion. What remains of these sediments now constitute the Raritan formation of the Coastal Plain, its outcrops forming the western border of the latter. Its strata, dipping to the southeast, are successively overlain by younger sediments so that in wells, like that at Asbury Park, several hundred feet of more recent materials are passed through before the Raritan clays and sands are encountered by the driller.

DESCRIPTION.

The Raritan formation is made up for the most part of alternating beds of clay and sand, with local lignitic deposits and gravel. They vary greatly horizontally, as well as vertically, so much so that the different members which are reasonably well defined in Middlesex County cannot be traced with any degree of assurance to the southwest. The clays are of various kinds, ranging from arenaceous, pyritiferous, at times laminated and lignitic clays, suitable only for the manufacture of common brick, to almost white, massive, high-grade fire clays. All of the clay beds are lenticular and some thin out and disappear in comparatively short distances. The sands are equally variable, some are sharp, nearly pure quartz, others are highly micaceous or lignitic or arkosic, and cross-bedding is frequently seen. The materials, as a whole, in both their character and rapid lateral variation, are just such deposits as would probably be found

along a subsiding estuary shore line. Comparable deposits are being laid down at the present time in Delaware Bay, Chesapeake Bay, the Gulf of California, and similar more or less land-locked estuarine bodies of water. The preserved fauna, while comparatively meager, shows fresh or brackish aquatic types with local instances of strictly marine forms which show that the country was low-lying and not much above sea level and subject to occasional inroads of the ocean waters. While it is not feasible to map the shifting members of the Raritan formation, it is still possible, especially in Middlesex County, where so many openings have been made, to divide the formation into the seven members shown diagrammatically in Figure 2. The basal con-

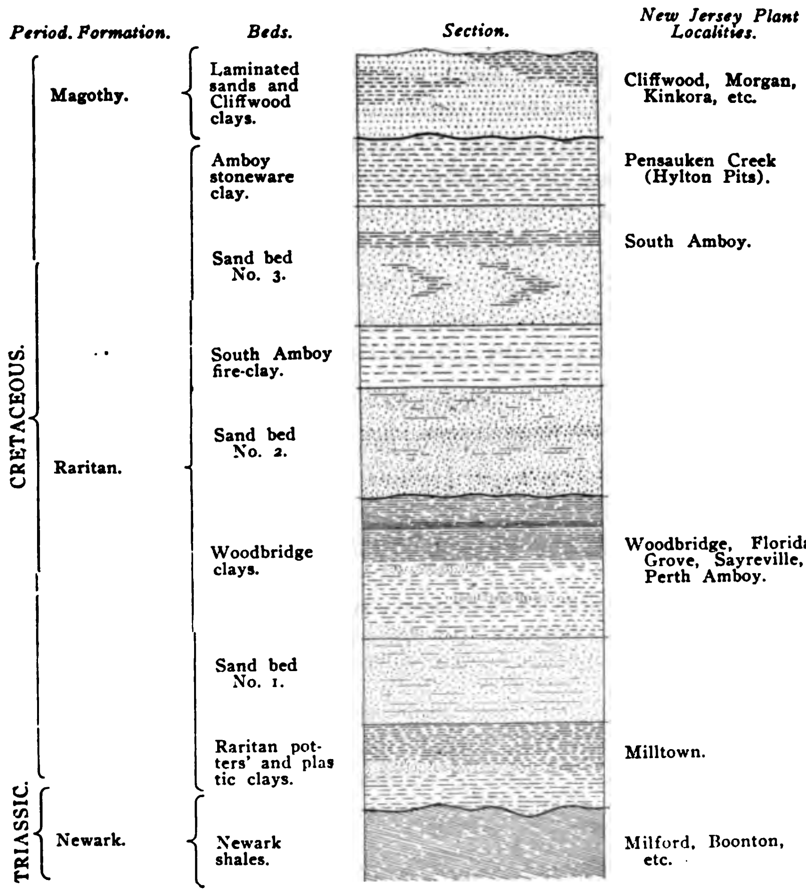

Fig. 2.—Ideal generalized columnar section of the Raritan and adjacent formations in Middlesex county, showing levels from which fossil plants have been collected.

tact, while usually deeply buried, is shown at a few localities in Middlesex County and is frequently encountered in well borings. South of Trenton the basal Raritan beds, in the absence of the Triassic, lie unconformably on the Philadelphia gneiss, or schist. The thickness of the formation varies considerably. Toward the northeast it is probably in the neighborhood of 260 feet, while just south of Trenton it is probably not over half that thickness. In a well boring in Delaware, a much (cf. Ft. Dupont) greater thickness has been encountered, but it must be admitted that the correlation of this section possesses considerable uncertainty. There seems to be evidence of a considerable thickening down the dip, if the well records can be relied upon. What the original thickness of the Raritan formation was is conjectural. It is certain, however, that post-Raritan erosion has removed much material.

At the close of Raritan sedimentation, the region was sufficiently elevated for erosion to attack the Raritan materials. This interval was not of long duration, however, when measured by geological standards, and the land was soon under water again, receiving the sediments that make up the Magothy formation and which toward their close mark the inauguration of true marine conditions, which became widespread in the succeeding formations of the Upper Cretaceous.

CORRELATION.

Passing over the somewhat diverse views of the older writers who were inclined to regard the Raritan as of Jurassic age,[1] we find Prof. Newberry, in 1890, recognizing the Amboy Clays as Cenomanian[2] in age and synchronous with the Dakota Group

[1] This age was also claimed for it by the late Prof. Marsh in several papers published a score of years ago.

[2] In continental Europe the Cretaceous system is divided as follows:

Upper Cretaceous.	Danian. Senonian. Turonian. Cenomanian.
Unconformity.	
Lower Cretaceous.	Albian. Aptian. Barremian. Neocomian.

of the West. Prof. Ward was the first to point out that the Raritan was older than the Dakota Group, which is undoubtedly the case, and it has been customary in recent years to regard the Raritan as roughly corresponding to the Gault of England and the Albian of continental Europe. The view here presented is that the Raritan flora is much more closely allied with the Cenomanian of the old world than it is with the Albian or Gault. At the same time it is quite obviously older than the Magothy flora, that of the Dakota Group and those of the South Atlantic Coastal Plain,[2] unless possibly the lower Tuscaloosa, of western Alabama, is equivalent to the upper Raritan in the vicinity of South Amboy, so that if these latter are to remain in the Cenomanian, they are to be regarded as Upper Cenomanian, in which case the Raritan may be regarded as Lower Cenomanian. European geology furnishes a similar case in the division of the Cenomanian into the substages Rotomagian and Caretonian, although probably the parallelism of substages cannot be carried across the ocean. European paleontology furnishes abundant and well characterized Cenomanian and Senonian floras for comparison, and by this standard the Raritan, as well as the somewhat younger Dakota and Magothy floras, are clearly Cenomanian floras. The Turonian stage of European geology, on the other hand, has thus far yielded so meager a flora that it is practically useless as a basis for comparison, and it may well be that the flora of the Dakota Group, along with its southern and eastern representatives—the Woodbine, Tuscaloosa, Eutaw, Middendorf, Bladen and Magothy floras, represent the Turonian stage of Europe. Stratigraphically, there is no contrary evidence and more or less of the Dakota sandstone would simply go with the overlying Benton, which invertebrate paleontologists have long considered as representing the Turonian of Europe. If this view is adopted it seems probable that the Raritan is to be correlated with a part of the upper Cenomanian of Europe.

The paleobotanical evidence for the Cenomanian age of the Raritan formation is briefly as follows: On general grounds,

[2] Older Cretaceous deposits are known from North Carolina to Alabama, but these are, in-so-far as known, unfossiliferous.

we find the Raritan flora more complex and modern in its composition than any known Albian flora; for example, dicotyledons make up 68% of the Raritan flora, while not a single dicotyledon is known from the English Gault, and the representation of this group of plants in the Albian of France and Spain is very meager indeed, and comparable to the display of these plants in the Patapsco formation of Maryland and Virginia, the latter showing a striking parallelism with the Albian of the old world, with at least one identical species and closely allied representatives in several identical genera.

Species which are peculiar to the Raritan formation number 54, as follows:

Acer amboyense Newb.
Aralia patens Holl.
Aralia rotundiloba Newb.
Asplenium raritanensis Berry.
Asplenium jerseyensis Berry.
Bauhinia gigantea Newb.
Cæsalpinia Cookiana Holl.
Caespalpinia raritanensis Berry.
Calycites diospyriformis Newb.
Calycites parvus Newb.
Carpolithus ovaeformis Newb.
Carpolithus pruniformis Newb.
Carpolithus woodbridgensis Newb.
Celastrophyllum grandifolium Newb.
Celastrophyllum minus Holl.
Celastrophyllum spatulatum Newb.
Chondrites flexuosus Newb.
Chondrophyllum obovatum Newb.
Chondrophyllum reticulatum Newb.
Cornophyllum vetustum Newb.
Dewalquea trifoliata Newb.
Diospyros amboyensis Berry.
Eucalyptus parvifolia Newb.
Fontainea grandifolia Newb.
Hedera obliqua Newb.
Ilex elongata Newb.

Ilex amboyensis Berry.
Laurophyllum lanceolatum Newb.
Laurophyllum minus Newb.
Leguminosites raritanenis Berry.
Liriodendron quercifolium Newb.
Menispermites Wardianus Hollick.
Myrica acuta Hollick.
Myrica cinnamomifolia Newb.
Myrica fenestrata Newb.
Myrica Hollicki Ward.
Myrica Newberryana Hollick.
Myrica raritanensis Hollick.
Myrsine oblongata Hollick.
Newberryana rigida (Newb.) Berry.
Passiflora antiqua Newberry.
Planera Knowltoniana Hollick.
Personia spatulata Hollick.
Phyllites trapaformis Berry.
Phyllites undulatus Newb.
Podozamites acuminatus Hollick.
Populus orbicularis (Newb.) Berry.
Protophyllum obovatum Newb.
Prunus ? acutifolia Newb.
Quercus raritanensis Berry.
Rhamnites minor Hollick.
Salix pseudo-Hayei Berry.
Sphaerites raritanensis Berry.
Williamsonia Smockii Newb.

Obviously these are of little service in correlation, nevertheless all but one or two are dicotyledons of genera, which in Europe are found only in the Cenomanian and Senonian. Allied forms are largely represented in the Magothy formation, the Dakota Group, and the Atane beds of Greenland.

There are 10 Lower Cretaceous species which persist into the Raritan. These are:

Asplenium Dicksonianum Heer.
Celastrophyllum Brittonianum Hollick.
Frenelopsis Hoheneggeri (Ettings.) Schenk.

Gleichenia giesekiana Heer.
Gleichenia micromera Heer.
Gleichenia Zippei Heer.
Podozamites Knowltoni Berry.
Podozamites lanceolatus (L. & H.) F. Braun.
Sequoia Reichenbachi (Gein.) Heer.
Thuyites Meriani Heer.

Of these the ferns and the gymnosperms, which make up the bulk of the list, are to be regarded primarily as Lower Cretaceous types which survived into the Upper Cretaceous. Among the generic types of ancient lineage which are represented in the Raritan, are *Baiera,* primarily a Triassic and Jurassic genus, the Raritan species of which is closely related to forms found in the Older Potomac, *Williamsonia* a Jurassic and Lower Cretaceous genus, *Brachyphyllum* a Triassic and Jurassic genus, the Raritan species of which is closely related to and clearly descended from *Brachyphyllum crassicaule* Font. of the Patapsco formation, and finally *Czekanowskia* a Triassic and Jurassic (chiefly Oolitic) genus.

In no part of the world has a single representative of any of these genera been found as late as the Senonian, and it is significant that two of them, *Brachyphyllum*[1] and *Czekanowskia* furnish their last known record in the Cenomanian of Portugal, while the last occurrence of *Baiera* and *Williamsonia*[2] is in the Cenomanian Atane beds of Greenland.

When the Raritan flora is compared in detail with the Patapsco flora of Maryland and Virginia, many common features are brought out which at first sight tend to be obscured by the preponderating dicotyledonous element in the former. In addition to the identical or closely related forms previously mentioned, we find among the dicotyledons five Raritan genera

[1] The Raritan species *B. macrocarpum* Newb. is recorded from the following American horizons: Montana Group of Wyoming, Dakota Group of Kansas, Magothy formation of Long Island, New Jersey and Delaware, the Middendorf of South Carolina (?), the Bladen of North Carolina (?), and the Patoot beds of Greenland (?), the former of course of Senonian age.

[2] A questionable species is recorded from the Dakota group and another species occurs in the Magothy formation.

which make their first appearance in the Patapsco. These are *Aralia, Celastrophyllum, Cissites, Eucalyptus* and *Ficus*. The genus *Celastrophyllum,* with a large display of forms in both the Patapsco and the Raritan, has one identical species, *C. Brittonianum* Hollick, while *C. Hunteri* of the former is very close and ancestral, if not actually identical, with *C. augustifolium* Newb. of the Raritan.

Among the conifers the widespread *Widdringtonites ramosus* (Font.) Berry, of the Patapsco, is closely related, if not identical, with the equally common *Widdringtonites Reichii* (Ettings.) Heer of the Raritan and succeeding formations. The genus *Frenelopsis* has closely related species in both, while *Sequoia* and *Thuyites* have already been mentioned as well as the cycadean genus *Podozamites* which extends back to the Triassic. Two Raritan species are recorded from the European Albian. These are *Sequoia Reichenbachi* (Gein.) Heer and *Eucalyptus angusta* Velen., the former a very wide ranging form and the latter recorded from the Albian of Portugal and the Cenomanian of Bohemia.

Turning to the elements in the Raritan flora which ally it with younger floras, we find that 6 of the Raritan species persist as late as the Senonian of Europe, and 15 are found in the Patoot beds of Greenland, which are also usually regarded as of Senonian age. All but 4 of these are, however, found in the Cenomanian beds of that country, and practically all of the others and those from the Senonian of Europe as well, occur somewhere in Cenomanian strata. There are 34 species common to the Raritan flora and that of the Dakota Group, the former lacking more particularly the numerous forms of *Betula, Quercus, Platanus,* etc., which characterize the latter. There are 32 species common to the Raritan and to the Atane beds of Greenland, the latter formation being usually regarded as Cenomanian in age, and there are 67 species common to the Raritan and Magothy floras, although these latter figures are somewhat obscured by the difficulty of determining the probable age of many of the species recorded from Long Island and other areas in the vicinity of the terminal moraine and by the additional fact that the Upper Raritan at South Amboy furnished many

of these identical species, and it is quite likely that some of the species credited to South Amboy, on the authority of Prof. Newberry, may really have come from within the Magothy formation, since the Morgan locality, which is of Magothy age, would not have been kept distinct from South Amboy as a place name in Prof Newberry's day. The following table of distribution gives in detail the geological and geographical distribution of all the species known to occur in the Raritan formation at the present time. The species found recorded from "near Keyport," in Prof. Newberry's report, are all excluded, as this outcrop is now known to be of Magothy age, while the *Tiliaephyllum* recorded from Fish House is now known to be Pleistocene. As previously mentioned, no account is taken of the determinations of Lesquereux, published in the Clay Report of 1878, since the material was so unreliable and embraced a number of forms which would be most unlikely to occur in these beds.

TABLE OF DISTRIBUTION.

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Acer amboyense Newb.,	—	×	—	—	×	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—
Acerates amboyense Berry,	—	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—
Andromeda grandifolia Berry,	—	—	—	—	×	—	×	×	—	?	—	×	—	—	×	—	—	—	—	—	—	—
Andromeda Cookii Berry,	—	—	—	—	×	—	×	×	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Andromeda novæ-cæsareæ Holl.,	—	×	—	—	—	—	—	—	—	—	×	×	×	—	×	—	—	—	—	—	—	—
Andromeda Parlatorii Heer,	—	—	×	—	—	—	—	×	×	×	×	×	—	—	×	×	×	—	—	—	—	—
Aralia formosa Heer,	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	×	—	—
Aralia grœnlandica Heer,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	×	×	—	—	—	—	—
Aralia Newberryi Berry,	—	—	—	—	×	—	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—
Aralia patens Hollick,	—	×	—	—	×	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Aralia quinquepartita Lesq.,	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—
Aralia rotundiloba Newb.,	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aralia Wellingtoniana Lesq.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—
**Asplenium Dicksonianum* Heer,	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—	×	×	—	—	—	—	—
Asplenium Fœrsteri D. & E.,	—	×	—	—	×	—	—	—	—	—	×	—	—	—	—	—	×	—	—	×	—	×
Asplenium raritanensis Berry,	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asplenium jerseyensis Berry,	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Baiera incurvata Heer,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Bauhinia cretacea Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—
Bauhinia gigantea Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brachyphyllum macrocarpum Newb.,	—	×	—	—	—	—	—	—	×	×	×	×	×	×	×	×	—	—	—	—	—	—

[1] The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

* Occurs in the Lower Cretaceous.

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Cæsalpinia Cookiana Holl.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cæsalpinia raritanensis Berry,		×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calycites diospyriformis Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calycites parvus Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Carpolithus floribundus Newb.,		—	—	—	×	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Carpolithus hirsutus Newb.,		—	—	—	×	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Carpolithus ovæformis Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Carpolithus pruniformis Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Carpolithus woodbridgensis Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Celastrus artica Heer,		×	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	×	—	—	—	—
**Celastrophyllum Brittonianum* Holl.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Celastrophyllum crenatum Heer,		×	—	—	—	—	×	—	—	—	—	×	×	—	×	—	—	×	—	—	—	—
Celastrophyllum cretaceum Lesq.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—
Celastrophyllum decurrens Lesq.,		×	—	—	×	—	—	×	—	—	—	—	—	—	—	×	—	—	—	—	—	—
Celastrophyllum grandifolium Newb.,		—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Celastrophyllum minus Holl.,	×	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Celastrophyllum Newberryanum Holl.,		×	—	—	—	—	×	—	—	—	×	—	—	—	—	—	?	—	—	—	—	—
Celastrophyllum spatulatum Newb.,		×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Celastrophyllum undulatum Newb.,		—	—	—	×	—	×	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—
Chondrites flexuosus Newb.,		—	—	—	×	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chondrophyllum obovatum Newb.,		—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chondrophyllum reticulatum Holl.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* Occurs in the Patapsco formation of Virginia

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Cinnamomum Newberryi Berry,	—	×	×	—	×	—	×	—	—	—	×	—	—	—	×	×	—	—	—	—	—	—
Cissites crispus Velen.,	—	×	—	—	×	—	—	—	—	—	?	—	—	—	—	—	—	—	—	×	—	—
Cissites formosus Heer,	—	×	—	—	×	—	×	—	—	?	—	—	—	—	—	×	×	—	—	—	—	—
Citrophyllum aligera (Lesq.), Berry,	—	×	—	—	—	—	—	—	—	—	×	×	—	—	—	×	—	—	—	—	—	—
Colutea primordialis Heer,	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—
Comptonia microphylla (Heer), Berry,	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—
Cornophyllum vetustum Newb.,	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cycadinocarpus circularis Newb.,	—	—	—	—	×	—	—	—	—	—	—	×	—	—	×	—	—	—	—	—	—	—
Czekanowskia capillaris Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—
Dammara borealis Heer,	—	—	—	—	×	—	—	—	×	×	×	×	—	—	×	—	×	—	—	×	—	—
Dalbergia apiculata Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dewalquea grœnlandica Heer,	×	—	—	—	—	—	—	—	×	—	×	×	—	—	×	—	×	×	—	—	—	—
Dewalquea trifoliata Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dicksonia grœnlandica Heer,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	×	—	×	×	—	—	—	—
Diospyros primæva Heer,	—	×	—	—	—	—	—	×	—	—	×	×	×	—	×	×	×	×	—	—	—	—
Diospyros amboyensis Berry,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eucalyptus angusta Velen.,	—	×	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	×	×	—	—
Eucalyptus attenuata Newb.,	—	×	×	—	—	—	—	—	—	—	×	×	—	—	×	—	—	—	—	—	—	—
Eucalyptus Geinitzi Heer,	—	×	—	—	×	—	×	×	×	—	×	×	×	—	×	×	×	—	—	×	—	—
Eucalyptus linearifolia Berry,	—	×	—	—	—	—	—	—	×	—	?	×	—	—	×	—	—	—	—	—	—	—
Eucalyptus parvifolia Newb.,	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ficus daphnogenoides (Heer), Berry,	—	×	—	—	×	—	×	×	×	—	×	×	×	—	×	×	—	—	—	—	—	—

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Ficus myricoides Holl.,	X	—	—	—	—	—	—	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Ficus ovatifolia Berry,	—	—	—	—	X	—	—	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Ficus Woolsoni Newb.,	—	—	X	—	X	—	X	—	X	—	X	—	—	—	X	—	—	—	—	—	—	—
Fontainea grandifolia Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
**Frenelopsis Hoheneggeri* (Ett), Schenk,	—	—	—	—	X	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—
Geinitzia formosa Heer,	—	—	—	—	X	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	X
**Gleichenia Gieseckiana* Heer,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	—	—
**Gleichenia micromera* Heer,	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—
**Gleischenia Zippei* Heer,	—	—	—	—	X	—	—	—	—	—	X	—	—	—	—	—	X	X	—	X	—	X
Hedera obliqua Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hedera primordialis Sap.,	—	—	—	—	X	—	—	—	—	—	—	X	X	—	—	—	X	—	—	X	—	—
Hymenæa dakotana Lesq.,	X	—	—	—	—	—	—	—	—	—	X	—	—	—	—	X	—	—	—	—	—	—
Ilex elongata Newb.,	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ilex amboyensis Berry,	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Juglans arctica Heer,	—	—	—	—	X	—	—	—	—	—	X	X	X	X	—	X	X	—	—	—	—	—
Juniperus hypnoides Heer,	—	—	—	X	X	—	—	—	X	—	X	—	—	—	—	—	X	—	—	—	—	—
Laurophyllum angustifolium Newb.,	—	—	—	—	X	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Laurophyllum elegans Holl.,	—	X	—	—	—	—	—	—	X	?	X	X	—	—	—	—	—	—	—	—	—	—
Laurophyllum lanceolatum Newb.,	—	—	—	—	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Laurophyllum minus Newb.,	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* Occurs also in the Lower Cretaceous.

[1] The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Laurophyllum nervillosum Holl.,	—	—	—	—	—	—	—	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—
Laurus plutonia Heer,	—	—	×	—	—	—	—	×	×	×	×	—	×	—	—	×	×	×	—	×	—	—
Leguminosites atanensis Heer,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	×	—	—	—	—	—
Leguminosites coronilloides Heer,	×	—	—	—	—	—	—	—	×	—	×	—	—	—	—	×	×	—	—	—	—	—
Leguminosites omphalobioides Lesq.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—
Leguminosites raritanensis Berry,	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Liriodendron oblongifolium Newb.,	—	—	—	—	×	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Liriodendron quercifolium Newb.,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Liriodendropsis angustifolia Newb.,	—	—	—	—	×	×	—	—	—	—	×	—	—	—	×	—	—	—	—	—	—	—
Liriodendropsis retusa (Heer), Newb.,	—	—	—	—	×	—	—	—	—	—	?	—	—	—	—	—	—	×	—	—	—	—
Liriodendropsis simplex Newb.,	—	—	×	—	×	—	—	×	×	?	×	—	—	—	×	—	—	—	—	—	—	—
Magnolia alternans Heer,	—	—	—	—	×	—	×	—	—	×	—	—	—	—	×	×	×	—	—	×	—	—
Magnolia Hollicki Berry,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	?	—	—	—	—	—	—	—
Magnolia Isbergiana Heer, ?	—	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	×	—	—	—	—	—
Magnolia Boulayana Lesq.,	—	—	—	—	×	—	—	—	—	—	×	—	—	×	×	×	—	—	—	—	—	—
Magnolia Lacœna Lesq.,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	×	—	—	—	—	—	—
Magnolia longipes Holl.,	—	—	—	—	×	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—
Magnolia Newberryi Berry,	—	—	—	—	×	—	—	—	×	—	×	×	—	—	×	—	—	—	—	—	—	—
Magnolia speciosa Heer,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	×	×	—	—	—	×	—	—
Magnolia woodbridgensis Holl.,	—	—	—	—	×	×	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Menispermites borealis Heer,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Menispermites Wardianus Holl.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Microzamia gibba (Reuss), Corda,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—
Moriconia cyclotoxon D. & E.,	—	×	—	—	—	—	—	—	×	—	—	—	—	—	—	—	×	×	—	—	—	×

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Myrica acuta Holl.,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrica cinnamomifolia Newb.,	—	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrica emarginata Heer,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	—	—	—
Myrica fenestrata Newb.,	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrica Hollicki Ward,	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrica Newberryana Holl.,	—	X	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrica raritanensis Holl.,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Myrsine borealis Heer,	—	X	—	—	—	—	—	X	—	—	X	X	—	—	X	—	X	—	—	—	—	—
Myrsine Gaudini (Lesq.), Berry,	—	X	—	—	—	—	—	X	X	?	—	X	—	—	X	X	—	—	—	—	—	—
Myrsine oblongata Holl.,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Newberryana rigida (Newb.), Berry,	—	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ophioglossum granulatum Heer,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—
Passiflora antiqua Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Phegopteris Grothiana Heer,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—
Phyllites undulatus Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Phyllites trapaformis Berry,	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pinus raritanensis Berry,	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Planera Knowltoniana Holl.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Persoonia spatulata Holl.,	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Persoonia Lesquereuxii Knowlton,	—	X	—	—	—	—	—	—	—	—	X	—	—	—	—	X	—	—	—	—	—	—
Phaseolites manhassettensis Holl.,	—	—	—	—	—	—	—	X	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Podozamites acuminatus Holl.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE OF DISTRIBUTION—*Continued.*

																			Europe.			
	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Albian.	Cenomanian.	Turonian.	Senonian.
Podozamites Knowltoni Berry,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Podozamites lanceolatus (L. & H.), F. Braun,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	×	—	—	—	×	—	—
Podozamites marginatus Heer,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	×	—	×	—	—	—	—	—
Populus apiculata Newb.,	—	—	—	—	×	—	—	—	×	×	×	—	—	—	×	—	—	—	—	—	—	—
Populus orbicularis (Newb.), Berry,	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Protophyllocladus subintegrifolius (Lesq.). Berry,	—	—	—	—	—	×	—	—	×	—	×	—	—	—	—	×	×	—	—	—	—	—
Prunus ? acutifolia Newb.,	—	×	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pterospermites obovatus (Newb.), Berry,	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quercus raritanensis Berry,	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhamnites minor Holl.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Raritania gracilis (Newb.), H. & J.,	—	×	—	—	×	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Salix flexuosa Newb.,	—	×	—	—	—	—	—	—	×	—	×	×	×	—	×	×	—	—	—	—	—	—
Salix inæqualis Newb.,	—	—	—	—	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—
Salix Newberryana Holl.,	—	×	—	—	×	—	×	×	—	—	—	×	—	—	—	—	—	—	—	—	—	—
Salix raritanensis Berry,	—	—	—	—	×	—	×	×	×	—	×	—	—	—	—	—	—	—	—	—	—	—
Salix Lesquereuxii Berry,	—	×	—	—	×	—	×	—	—	—	×	×	—	—	—	×	—	—	—	—	—	—
Salix pseudo-Hayci Berry,	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sassafras acutilobum Lesq.,	—	—	—	—	×	—	—	×	—	—	×	×	—	—	—	×	—	—	—	×	—	—
Sassafras hastatum Newb.,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Sassafras progenitor Holl.,	—	—	—	—	×	—	—	—	—	?	×	—	—	—	—	—	—	—	—	—	—	—
Sequoia concinna Heer.	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—

[1] The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.	South Carolina.	Georgia.	Alabama.	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Europe. Cenomanian.	Europe. Turonian.	Europe. Senonian.
Sequoia heterophylla Velen.,	—	×	×	—	—	—	—	—	×	—	×	×	—	—	×	—	—	—	—	×	—	×
[1]*Sequoia Reichenbachi* (Gein.), Heer,	—	—	—	—	×	—	—	—	—	—	×	×	×	×	×	×	—	—	×	×	—	×
Smilax raritanensis Berry,	×	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—
Sphærites raritanensis Berry,	—	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tricalycites papyraceus Newb.,	—	×	—	—	×	—	—	—	×	?	×	—	—	—	×	—	—	—	—	—	—	—
Tricarpellites striatus Newb.,	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—
Thuya cretacea (Heer), Newb.,	—	×	—	—	—	—	—	—	—	—	×	—	—	—	—	—	×	—	—	—	—	—
[1]*Thuyites Meriana* Heer,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—
Viburnum integrifolium Newb.,	—	—	—	—	×	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Widdringtonites Reichii (Ett.), Heer,	—	×	×	—	×	—	×	×	×	—	×	—	—	—	×	—	×	×	—	×	—	—
Widdringtonites subtilis Heer,	—	×	—	—	×	—	—	—	—	—	×	—	×	—	×	—	×	—	—	—	—	—
Williamsonia Smockii Newb.,	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Williamsonia problematica (Newb.), Ward,	×	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	—	—	—

[1] Recorded also in the Lower Cretaceous.

IV. BOTANICAL CHARACTER.

The present enumeration of Raritan plants embraces between 160 and 170 species. Of this number there are from 15 to 20 whose botanical relations are unknown. The balance show the following disposition in the great phylæ of the vegetable kingdom: Two Thallophytes are recorded, one a fungus and the other an alga. Doubtless other representatives of this great plant phylum were abundant during Raritan time, and possibly other species could be recorded, but they are so vague in their characters as to be of little value, except in so far as they show the presence of these types of plants at this remote epoch.

The Pteridophytes, or fern-plants, are represented by 9 species, or .055% of the whole flora. In the existing flora of New Jersey the percentage is .038%, but this is lowered by herbaceous plants which are absent from the fossil record. Thus the Raritan record shows a remarkable shrinkage as compared with floras of the older Mesozoic. The species present in the New Jersey beds are all wide-ranging forms of little peculiar interest in this connection, and they fall in those Cretaceous groups which represent the modern families, Gleicheniaceæ, Cyatheaceæ, Polypodiaceæ and Ophioglossaceæ. The ferns are more abundant in the Raritan formation than they are in the Magothy formation or the Dakota group, while they are considerably less abundant than in the flora of the Atane beds of Greenland, where they constitute 11% of the whole flora.

As might be expected, the great bulk of the Raritan plants belong to the Spermatophyta, or seed-plants, and of these 24 are referred to the Gymnospermæ, almost twice as many as are present in the recent gymnospermous flora of the State. These are relatively much more abundant, both in individuals and in species, than they are in the Tertiary or recent floras. Six are referred to the cycads, one of which is based on a cone, one on seed remains, and the balance on frond fragments. The older Mesozoic abounded in cycadophytes, which at that time were

world-wide in their distribution, and they maintained their position with unabated vigor during most of the Lower Cretaceous. During the Upper Cretaceous, however, they commenced to wane, a prophetic hint of their minor position and restricted range in the floras of the modern world, where they have only 9 genera and less than 100 species. Two of the Gymnospermæ, a *Baiera* and a *Czekanowskia,* are referred to the Ginkgoales, that singular order whose sole surviving representative is the Maidenhair tree indigenous in eastern Asia, and commonly cultivated as an ornamental tree in our parks. This order was a very important element in the older Mesozoic, and its two representatives in the Raritan are to be regarded as surviving elements from the Jurassic. They are both confined to the lower Raritan. This leaves 16 species of the order Coniferales, or true conifers, the order to which all of the gymnosperms in the recent flora of New Jersey belong. The family Taxaceæ, which is well represented in the older Potomac formations of Maryland and Virginia, has but one species in the Raritan, *Protophyllocladus subintegrifolius* (Lesq.) Berry, of the sub-family Taxæ. Its botanical affinity is not established with certainty, although superficially it is strikingly like the modern antipodean genus *Phyllocladus.* The balance of the Coniferales are referred to the family Pinaceæ, 4 sub-families being represented. The sub-family Abieteæ includes a species of *Pinus*, which is first seen in the Upper Raritan at South Amboy and which persists into the Magothy formation and is also present in the Upper Cretaceous deposits in the Carolinas. Other species are also present in the Magothy formation along with fossil wood, and it is to this genus that the abundant amber of that formation is said to owe its origin. The sub-family Araucarieæ, at the present day confined to the southern hemisphere, but cosmopolitan in the older Mesozoic, is represented by 2 Raritan species, *Dammara borealis* Heer, based on deciduous cone scales, and *Brachyphyllum macrocarpum* Newb., based on leafy twigs. The latter is known only from the Upper Raritan, but, nevertheless, represents a Jurassic and Lower Cretaceous type, of which it is about the last representative.

The sub-family Taxodieae is represented by 2 or 3 species of *Sequoia* and 1 of *Genitzia*, all forms with a considerable geographical range. The sub-family Cupresseae makes the greatest display in species during Raritan time, with no less than 8 recorded forms. These include a species of *Thuja*, another of *Thuyites*, a wide-ranging *Juniperus*, *Moriconia*, and 2 species each in *Widdringtonites* and *Frenelopsis*. Modern botanists include both of the latter genera as synonyms of the genus *Callitris*, but there is considerable advantage and good arguments for maintaining their distinctness. *Widdringtonites Reichii* (Ett.) Heer is abundant throughout the Raritan and Magothy formations and is undoubtedly descended from the closely allied form of the older Potomac. *Widdringtonites subtilis* Heer, although present in the lower Raritan at Woodbridge, is more characteristic of the somewhat later Upper Cretaceous deposits of the Atlantic Coastal Plain. One species of *Frenelopsis* is a survivor from the Lower Cretaceous, and the other is a characteristic form in the overlying Magothy formation in New Jersey, Delaware and Maryland. In some respects the most interesting member of the sub-family is *Moriconia cyclotoxon* Deb. & Ett. described originally from the European Senonian of Aachen and thought to be a fern. Afterward discovered by Heer in both the Cenomanian and Senonian beds of Greenland, it appears in the upper Raritan at South Amboy.

The Angiospermae, or plants with closed ovaries, usually designated as "flowering plants," make up the balance of the flora. These are nearly all dicotyledons. Monocotyledons are usually less fully represented in fossil floras than are the dicotyledons, which not only have leaves differentiated into blade and leaf stalk, but have these parts more resistant to maceration, so that the absence of monocotyledons may simply mean that none were preserved, although there are very plausible theoretical reasons for regarding the monocotys as a comparatively modern offshoot from the older dicotys. The monocotyledon known from the Raritan formation is the single species of *Smilax* to which genus the writer has transferred Prof. Newberry's species of *Paliurus*, and as this is a rare and not especially significant element in the flora, it may be passed without further consideration.

Turning to the Dicotyledonæ, we find the old group Amentiferæ, which by some authors are thought to be reduced higher plants and by others considered primitive and as partially bridging the gap between the Angiospermæ and the order Gnetales of the Gymnospermæ, has 18 species, or 14%, in the Raritan. These include 8 species of Myricales, 1 of Juglandales, 8 of Salicales and 1 of Fagales. This is a considerable less showing than is made by this type in the flora of the Dakota Group, where there are 10 species of Myricales, 6 of Juglandales, 24 of Salicales and 44 of Fagales.

The order Urticales has a species of *Planera* and 4 species of *Ficus* in the Raritan, the latter including both the lanceolate pinnately-veined forms and those with a palmate venation. This order is much more fully represented in immediately succeeding floras, the Dakota Group having over a score of species, and the Senonian, both at home and abroad, a great variety.

The order Proteales, which in modern floras is confined to the southern hemisphere, has but 2 Raritan species, while there are 6 in the Dakota Group. Later geologic time shows a considerable development of this order, especially in the Tertiary of Europe.

The order Ranales, recently given a prominent place in phylogenetic speculations by English authors, who, on purely theoretical grounds, would connect the Angiospermae through this medium with the Mesozoic Cycadophyta, has 24 species in the Raritan, or 19% of its known flora. This is a much less number than is present in the Dakota Group, from which 81 species are recorded. In the Raritan there are 2 species of *Dewalquea*, 9 or 10 of *Magnolia*, 2 of *Liriodendron*, 3 of *Sassafras*, and 2 species of *Menispermites*. At the present day this order is represented in the latitude of New Jersey by mostly herbaceous forms of the family Ranunculaceae, the arborescent forms related to those of the Raritan being largely warm-temperate or subtropical species of wide distribution, strongly represented in northern South America.

The large modern order Rosales has 431 species in the area covered by Britton and Brown's Illustrated Flora of the United States, while in Small's Flora of the Southern United States

over 800 species are recorded. The Raritan flora furnishes 16 species, or 13% of the total, and these belong for the most part to the various families into which the old family Leguminoseae has been split by modern systematists. A large number of these Raritan species are based upon leaflets, whose generic relations are not determinable with certainty. Deserving of special mention are the 2 species of *Bauhinia* which have such striking bilobate leaves and which are well characterized and closely related to existing forms in the American tropics.

The order Geraniales is represented in the upper Raritan of South Amboy by a single specimen of *Citrophyllum aligera* (Lesq.) Berry, a widespread species in the overlying Magothy formation and in the Dakota Group, and with modern subtropical affinities.

In the order Sapindales there are 13 species, or 11% of the total. They include a somewhat doubtful species of *Acer,* 2 of *Ilex,* and a *Celastrus,* which is very abundant and is characteristic of the upper Raritan. The genus *Celastrophyllum,* which appears in abundance in the Older Potomac flora of Maryland and Virginia, is especially abundant in the Cretaceous of the Atlantic Coastal Plain. There are 9 species in the Raritan flora, several of which are especially well marked and some are of large size. *Celastrophyllum crenatum* Heer ranged from Greenland to South Carolina, and *Celastrophyllum Newberryanum* Hollick is an especially abundant leaf in the upper Raritan at South Amboy, occuring also in the older Raritan deposits at Sayreville. It has not been possible to determine from what horizons in the Raritan *Celastrophyllum Brittonianum* Hollick, and *cretaceum* Lesq. were collected, which is unfortunate, since the former has also been found in the older Patapsco formation and the latter in the younger Dakota Group.

There are 5 species of Rhamnales and 1 species of Parietales in the Raritan, the genera present being *Rhamnites, Hedera, Cissites,* and *Passiflora.*

The order Myrtales, which includes quite a number of herbaceous species in the modern flora of this region, is represented in the Raritan by 6 species of *Eucalyptus,* 4 of which are confined to the upper Raritan at South Amboy. This genus has

been recorded from a large number of Cretaceous localities and becomes even more cosmopolitan in the Tertiary, but is restricted in modern times to the Australian region.

There are 9 Raritan species of Umbellales, forming 7% of the angiosperms represented. This is about one-third the number present in the Dakota Group. These include 7 species of *Aralia* whose modern relatives are to be found in allied genera of the warmer regions of the globe. There is a very doubtfully identified species of *Viburnum* and a species of *Cornophyllum* which is closely allied to species of *Cornus* found in the Magothy and Tuscaloosa formations, the Atane beds and the Dakota Group.

The order Ericales has 4 species of *Andromeda* in the Raritan flora, and the order Primulales has 3 species of *Myrsine*, all with an outside distribution and with modern representatives in warmer climes.

The order Ebenales is represented by 3 species of *Diospyros*, one of which is very abundant both in New Jersey and elsewhere; and the order Gentianales is represented by a single species of *Acerates*.

While the flora as a whole differs from any modern American flora with which it may be compared by the association of forms which have since become segregated by the diversified climate of later geological time, it is distinctly suggestive of existing floras, meaning by this that it is the earliest known flora in which the same plant groups which dominate in the present flora of the globe are largely represented.

Of the 78 genera known from the Raritan formation, only 32 are extinct, and 11 of these genera are gymnosperms, or lower plants, and of the remainder about a dozen belong to genera like *Calycites, Carpolithus, Palaeanthus, Leguminosites*, etc. Of the 45 known genera of Raritan Angiospermae, only 11 have since passed entirely away.

With the exception of the Araucarieæ, Proteaceæ and Eucalyptus, which have since become gradually restricted to the southern hemisphere, we would have no difficulty in acclimitizing the Raritan flora in our present Gulf States, and the modern representatives of the groups since become antipodean would flourish

in such an environment if they were reintroduced, at least the only adverse factor would be the pressure of a more complex flora. This, incidentally, seems to have been the ancient factor which largely explains their present distribution.

With regard to the climate of the Raritan, the data for forming any adequate opinion are altogether insufficient. Although *Widdringtonites* and *Frenelopsis* suggest a certain amount of aridity, this is overwhelmingly opposed by the ferns and cycads and a host of other forms. The climate was certainly more uniform than at present, both as regards seasonal changes and zonal differentiation.

When large numbers of identical species range from Greenland through southern New England, New Jersey, Maryland, and the Carolinas to Alabama, and when we find identical Dakota Group forms in Minnesota and Kansas and then in Texas, and then in the Upper Cretaceous of Patagonia, it would seem that the proof that Cretaceous climate was very different, as a whole, from modern climate rested on a very secure foundation.

V. GEOGRAPHICAL DISTRIBUTION.

OCCURRENCE IN NEW JERSEY.

Identifiable remains of leaves are by no means uniformly distributed in the Raritan formation, even in the argillaceous beds. On the contrary, good material is extremely local. Traces of former vegetation are much more abundant, as shown by the black clays, with "hacksel," as the Germans term comminuted vegetable material, and by beds of lignite which are sometimes several feet in thickness. Usually, however, where leaf remains occur in these black clays or in the presence of much lignite, they are so impregnated with ulmic or carbonaceous matter that they are very perishable. This is especially true of material collected around Sayreville and applies with equal force to numerous other leaf-bearing outcrops. The bulk of Prof. Newberry's material came from one pit in the Woodbridge district (Cutter pit), and the writer's best material comes from a single pit at South Amboy (Allen and Clark pit).

There are 24 species for which there are no exact data as to locality or horizon. These include a number of species which occur elsewhere in older or younger strata and whose position in the Raritan would be a matter of considerable interest. Among them may be mentioned:

Celastrophyllum Brittonianum Hollick.
Celastrophyllum cretaceum Lesq.
Delwalquea groenlandica Heer.
Hymenaea dakotana Lesq.
Sequoia concinna Heer.
Thuyites meriani Heer.

What appears to be one of the lowest leaf-bearing horizons in the Raritan is that near its western border, at Milltown, from which the following species have been collected by Charles H. Mead of that place and by Ward and White of the U. S. Geo-

logical Survey, all collected during 1892 and contained in the collections of the U. S. National Museum:

Andromeda Cookii Berry.
Andromeda grandifolia Berry.
Andromeda Parlatorii Heer.
Asplenium Dicksonianum Heer.
Asplenium jerseyensis Berry.
Celastrophyllum angustifolium Newb.
Celastrophyllum minus Hollick.
Cornophyllum vetustum Newb.
Diospyros primaeva Heer.
Eucalyptus Geinitzi Heer.
Ficus ovatifolia Berry.
Ficus myricoides Hollick.
Ficus daphnogenoides Berry.
Gleichenia micromera Heer.
Laurophyllum lanceolatum Newb.
Laurophyllum nervillosum Heer.
Laurus plutonia Heer.
Liriodendropsis simplex Newb.
Magnolia isbergianna Heer (?)
Myrica fenestrata Newb.
Myrica Hollicki Ward.
Myrica Newberryana Hollick.
Myrsine borealis Heer.
Myrsine elongata Newb.
Phaseolites manhassettensis Hollick.
Salix Newberryana Hollick.
Salix membranacea Newb.
Salix pseudo-Hayei Berry.
Sassafras acutilobum Lesq.
Widdringtonites Reichii Heer.

This florule of but 30 species is far from representative and contains no elements which can be regarded as allying it with the older Potomac flora as developed in Maryland and Virginia.

The following species are recorded from the north bank of the Raritan, just east of Florida Grove, from the upper layers of the Woodbridge clay series:

Protophyllocladus subintegrifolius (Lx.) Berry.
Magnolia woodbridgensis Hollick.
Ilex (?) *elongata* Newb.
Liriodendropsis angustifolia Newb.

These were striking enough when collected, but very perishable and furnish no data of especial interest, since much larger collections have been made from approximately the same horizon at Woodbridge and Sayreville.

From the immediate vicinity of Sayreville, where the material is much like that from the preceding locality, and comes from the same general level, the Woodbridge clays, the following species have been obtained:[1]

Andromeda grandifolia Berry.
Andromeda Cookii Berry.
Celastrophyllum crenatum Heer.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum undulatum Newb.
Chondrites flexuosus Newb.
Cinnamomum Newberryi Berry
Cissites formosus Heer.
Comptonia microphylla (Heer) Berry.
Eucalpytus Geinitzi (Heer) Heer.
Ficus daphnogenoides (Heer) Berry.
Ficus Woolsoni Hollick.
Gleichenia micromera Heer.
Ilex elongata Newb.
Ilex amboyensis Berry.
Magnolia alternans Heer.
Myrica fenestrata Newb.
Populus orbicularis (Newb.) Berry.
Quercus raritanensis Berry.
Salex Newberryana Hollick.
Salex membranaceae Newb.

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[1] Some few of these were collected by the writer from the Sayre & Fisher pits. The balance are credited to this locality on the authority of Professor Newberry's collections and undoubtedly are from this same locality and horizon.

Salex Lesquereuxi Berry.
Widdringtonites Reichii (Ettings.) Heer

Among these the *Gleichenia* is the only striking old form, and a number like *Salix Lesquereuxi* range considerably higher than the Raritan.

Only *Juniperus macilenta* Heer, described originally from the Atane beds of Greenland, is recorded from Perth Amboy.

By far the largest number of species from a single locality is that recorded from Woodbridge, where the Woodbridge clays have furnished the basis of an important industry for so many years. This locality has yielded 94 species, most of which were collected from Prof. Newberry or his assistants from the Cutter pits:

Acer amboyense Newb.
Andromeda grandifolia Berry.
Andromeda Cookii Berry.
Aralia groenlandica Heer.
Aralia Newberryi Berry.
Aralia patens Hollick.
Aralia quinquepartita Lesq.
Aralia rotundiloba Newb.
Aralia Wellingtoniana Lesq.
Asplenium Dicksonianum Heer.
Asplenium Foersteri Deb. & Ettings.
Biera incurvata Heer.
Bauhinia cretacea Newb.
Bauhinia gigantea Newb.
Calycites diospyriformis Newb.
Calycites parvus Newb.
Carpolithus floribundus Newb.
Carpolithus hirsutus Newb.
Carpolithus ovæformis Newb.
Carpolithus pruniformis Newb.
Carpolithus woodbridgensis Newb.
Celastrophyllum decurrens Lesq.
Celastrophyllum undulatum Newb.
Chondrites flexuosus Newb.

Chondrophyllum obovatum Newb.
Cinnamomum Newberryi Berry.
Cissites crispus Velen.
Cissites formosus Heer.
Colutea primordialis Heer.
Cornophyllum vetustum Newb.
Cycadinocarpus circularis Newb.
Czekanowskia capillaris Newb.
Dammara borealis Heer.
Dalbergia apiculata Newb.
Dewalquea trifoliata Newb.
Dicksonia groenlandica Heer.
Diospyros amboyensis Berry.
Eucalyptus Geinitzi (Heer) Heer.
Ficus daphnogenoides (Heer) Berry.
Ficus ovatifolia Berry.
Ficus Woolsoni Hollick.
Fontainea grandifolia Newb.
Frenelopsis Hoheneggeri (Ettings.) Schenk.
Geinitzia formosa Heer.
Gleichenia Giesekiana Heer.
Gleichenia Zippei Heer.
Hedera obliqua Newb.
Hedera primordialis Sap.
Juglans artica Heer.
Juniperus hypnoides Heer.
Laurophyllum angustifolium Newb.
Laurophyllum lanceolatum Newb.
Liriodendrom oblongifolium Newb.
Liriodendrom quercifolium Newb.
Liriodendropsis angustifolia Newb.
Liriodendropsis retusa (Heer) Hollick.
Liriodendropsis simplex (Newb.) Newb.
Magnolia alternans Heer.
Magnolia Hollicki Berry.
Magnolia Boulayana Lesq.
Magnolia Lacoena Lesq.
Magnolia longipes Hollick.

Magnolia Newberryi Berry.
Magnolia speciosa Heer.
Magnolia woodbridgensis Hollick.
Menispermites borealis Heer.
Microzamia gibba (Reuss) Corda.
Myrica cinnamomifolia Newb.
Newberryana rigida (Newb.) Berry.
Passiflora antiqua Newb.
Phegopteris Grothiana Heer.
Phyllites undulatus Newb.
Planera Knowltoniana Hollick.
Podozamites lanceolatus (L. & H.) F. Braun.
Podozamites marginatus Heer.
Populus apiculata Newb.
Protophyllum obovatum Newb.
Prunus acutifolia Newb.
Raritania gracilis (Newb) H. & J.
Salix inæqualis Newb.
Salix Newberryana Hollick.
Salix raritanensis Berry.
Salix Lesquereuxii Berry.
Sassafras acutilobum Lesq.
Sassafras hastatum Newb.
Sassafras progenitor Hollick.
Sequoia Reichenbachi (Gein.) Heer.
Tricalycites papyraceus Newb.
Tricarpellites striatus Newb.
Viburnum integrifolium Newb.
Widdringtonites Reichii (Ettings.) Heer.
Widdringtonites subtilis Heer.

As determined by the stratigraphy, these are approximately of middle Raritan age. Paleontologically they are closely allied with the more meager florules previously enumerated, the weight of the paleobotanical evidence showing that the Raritan flora falls naturally into two divisions, an older and a younger. There are 76 species which do not occur in the Upper Raritan, of which 10 occur in the Lower Cretaceous.

The younger or Upper Raritan flora is known from two localities, the one at the Allen Pits at South Amboy, which has furnished the bulk of the species; the other at the Hylton Pits along Pensauken Creek (near Palmyra), where the top of the Raritan is slightly exposed and unconformably overlain by the arenaceous strata of the Magothy formation, which makes up the bulk of the exposure. The following species are recorded from these two localities:

Acer amboyensis Newb.
Acerates amboyense Berry.
Andromeda novæ-cæsareæ Hollick.
Andromeda Parlatorii Heer.
Aralia formosa Heer.
Aralia patens Hollick.
Aralia quinquepartita Lesq.
Arelia rotundiloba Newb.
Asplenium Foersteri Deb. & Ettings.
Asplenium raritanensis Berry.
Brachyphyllum macrocarpum Newb.
Cæsalpinia raritanensis Berry.
Celastrus arctica Heer.
Celastrophyllum crenatum Heer.
Celastrophyllum decurrens Lesq.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum spatulatum Newb.
Cinnamomum Newberryi Berry.
Cissites crispus Vel.
Cissites formosus Heer.
Citrophyllum aligerum Berry.
Colutea primordialis Heer.
Diospyros primæva Heer.
Eucalyptus angusta Vel.
Eucalyptus attenuata Newb.
Eucalyptus Geinitzi (Heer) Heer.
Eucalyptus linearifolia Berry.
Eucalyptus parvifolia Newb.
Ficus daphnogenoides (Heer) Berry.

Ficus Woolsoni Hollick.
Laurophyllum elegans Hollick.
Laurophyllum minus Newb.
Laurus plutonia Heer.
Leguminosites raritansis Berry.
Liriodendropsis simplex Newb.
Moriconia cyclotoxon Deb. & Ettings.
Myrica cinnamomifolia Newb.
Myrica Newberryana Hollick.
Myrsine borealis Heer.
Myrsine elongata Hollick.
Newberryana rigida Berry.
Pinus raritanensis Berry.
Persoonia Lesquereuxii Knowlton.
Phyllites trapaformis Berry.
Prunus acutifolia Newb.
Raritania gracilis (Newb.) H. & J.
Salix flexuosa Newb.
Salix Newberryana Hollick.
Salix Lesquereuxi Berry.
Sequoia heterophylla Vel.
Sphærites raritanensis Berry.
Tricalycites papyraceus Newb.
Thuja cretacea Newb.
Widdringtonites Reichii Heer.
Widdringtonites subtilis Heer.

Of these 56 species 27 do not occur in the more abundant material from the lower Raritan horizons, and many of them are species which characterize more particularly the overlying Magothy formation or were described originally from the Cenomanian of Europe, the Atane and Patoot beds of Greenland, or the Dakota Group of the West, all of which are younger in age. Twelve of the genera are not even represented in the older Raritan, and, aside from these, certain species like *Andromeda novæ-cæsareæ* Holl, *Brachyphyllum macrocarpum* Newb., *Citrophyllum aligera* (Lesq.) Berry, *Eucalyptus angusta* Velen., *Salix flexuosa* Newb., *Sequoia heterophylla* Velen. are the character-

istic fossils of the Magothy and allied Upper Cretaceous formations over a wide area. This is interpreted as due to the gradual evolution of the Raritan flora, and does not seem of sufficient weight to warrant the uniting of the Upper Raritan beds with the Magothy formation, since, as previously mentioned, some of Newberry's data are questionable, and the only well-marked stratigraphic break occurs above the South Amboy plant horizon at the eroded summit of the Amboy stoneware clay.

ORIGIN AND RADIATION.

A great many of the Raritan species appeared at approximately the same time in the western interior, the Arctic regions and central Europe. The fact that these floras are all so different from those of Lower Cretaceous age and that they contain so predominating an element of dicotyledonous plants renders any inquiry into their place of origin or their ancestral forms a subject of surpassing interest.

There are no adequate data for a phylogenetic discussion which is not purely speculative, the present desideratum being a knowledge of those primitive forms from the Older Potomac and an acquaintance with the flora which flourished while the Schooley peneplain was being developed.

A number of the immediate ancestors of Raritan species are, however, represented in the flora of the Patapsco formation of Maryland and Virginia, others are undoubted immigrants from elsewhere. Where did this mid-Cretaceous flora take its origin? A number of answers are suggested. First, it may have originated in eastern or central Asia, which is an old continental mass, and spread from there westward into Europe and northeastward into the Arctic regions and North America. As previously mentioned, it is recorded from Europe, America and the Arctic regions. It may have originated in Europe and migrated from thence across the Arctic to America, or it may have originated in America and migrated in a reverse direction. The somewhat earlier appearance of more modern types toward the close of the Lower Cretaceous and the somewhat more advanced organization of the Upper Cretaceous floras of America as compared with those of Europe renders the former supposition improbable

Eastern America during the long interval of elevation and erosion, which occupied all of Jurassic time, offers many potential possibilities as a theater of evolution, as it undoubtedly was, but the simultaneous appearance of identical types in the mid-Cretaceous of Europe and America and Greenland is hard to understand if either America or Asia was the center of dispersal. The remaining alternative is that of regarding the Arctic area as the scene of evolution and center of dispersal of the modern flora, and, possibly, the fauna as well. The facts, while suggestive, are insufficient for definite conclusions. They serve to explain, for instance, the presence of the oldest known *Comptonia* in deposits in Greenland, New Jersey, Sweden and Bohemia, which are probably all of Cenomanian age; the presence of *Moriconia* from Greenland southward to South Carolina on this continent and in central Europe at the same time. In fact, numberless parallels could be drawn between the Albian and Cenomanian of America and Europe, so that at least tentatively we may picture successive waves of plant migration sweeping southward from the Arctic region somewhat as indicated by the arrows in Figure 3, the recorded floras of middle and later Cretaceous age being indicated by the solid black areas.

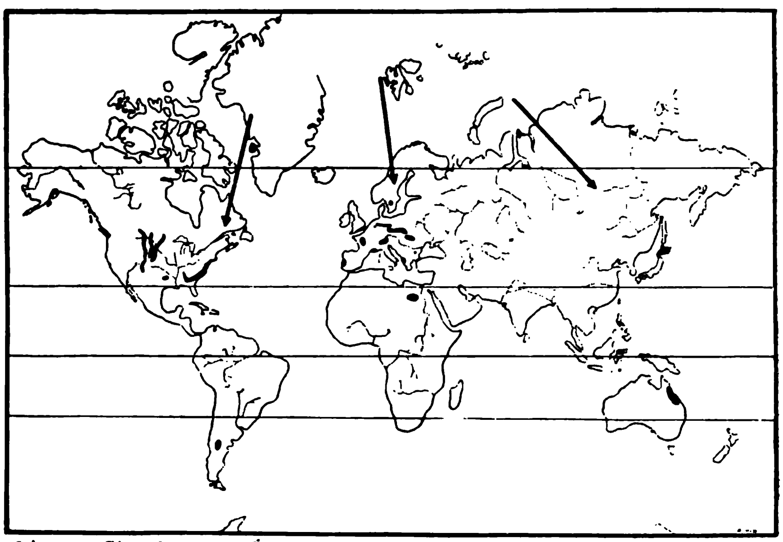

Fig. 3.—Sketch map of the world, showing approximate location of mid-Cretaceous plant-bearing deposits (in black). Arrows indicate possible directions of migration.

PART II.

Systematic Paleobotany.

SPECIES DESCRIBED.

PHYLUM THALLOPHYTA.

Class Fungi.

Order Pyrenomycetes.

Sphærites raritanensis Berry.

Class Algæ.

Chondriteæ.

Chondrites flexuosus Newb.

PHYLUM PTERIDOPHYTA.

Order Filicales.

Family Ophioglossaceæ.

Ophioglossum granulatum Heer.

Family Gleicheniaceæ.

Gleichenia Giesekiana Heer.

Gleichenia micromera Heer.

Gleichenia Zippei Heer

Family Cyatheaceæ.

Dicksonia groenlandica Heer.

Family Polypodiaceæ.

Asplenium raritanensis Berry.

Asplenium Dicksonianum Heer.

Asplenium jerseyensis Berry.

Asplenium Foersteri Deb. & Ett.

Phegopteris Grothiana Heer.

PHYLUM SPERMATOPHYTA.

Class Gymnospermæ.

Order Cycadales.

Podozamites Knowltoni Berry.

Podozamites lanceolatus (L. & H.) F. Braun.

Podozamites marginatus Heer.

Podozamites acuminatus Hollick.

Microzamia gibba (Reuss) Corda.
Cycadinocarpus circularis Newb.
Order Coniferales.
Family Pinaceæ.
Sub-family Araucarieæ.
Dammara borealis Heer.
Brachyphyllum macrocarpum Newb.
Sub-family Abieteæ.
Pinus raritanensis Berry.
Sub-family Taxodieæ.
Sequoia heterophylla Velen.
Sequoia Reichenbachi (Gein) Heer.
Sequoia concinna Heer.
Geinitzia formosa Heer.
Sub-family Cupresseæ.
Thuya cretacea (Heer) Newb.
Thuyites Meriani Heer.
Juniperus macilenta Heer.
Moriconia cyclotoxon Deb. & Ett.
Widdringtonites Reichii (Ett.) Heer.
Widdringtonites subtilis Heer
Frenelopsis Hoheneggeri (Ett.).
Schenk.
Raritania gracilis (Newb.) H. & J.
Family Taxaceæ.
Sub-family Taxeæ.
Protophyllocladus subintegrifolius
(Lesq.) Berry.
Order Ginkgoales.
Baiera incurvata Heer.
Czekanowskia capillaris Newb.
Class Angiospermæ.
Sub-class Monocotyledonæ.
Order Liliales.
Family Smilaceæ.
Smilax raritanensis Berry.

Sub-class Dicotyledonæ.

Order Myricales.

Family Myricaceæ.

Myrica Hollicki Ward.
Myrica emarginata Heer.
Myrica Newberryana Hollick.
Myrica fenestrata Newb.
Myrica cinnamomifolia Newb.
Myrica acuta Hollick.
Myrica raritanensis Hollick.
Comptonia microphylla (Heer) Berry.

Order Juglandales.

Family Juglandaceæ.

Juglans artcica Heer.

Order Salicales.

Family Salicaceæ.

Populus orbicularis (Newb.) Berry.
Populus apiculata Newb.
Salix flexuosa Newb.
Salix Lesquereuxii Berry.
Salix raritanensis Berry.
Salix inæqualis Newb.
Salix Newberryana Hollick.
Salix pseudoHayei Berry.

Order Fagales.

Family Fagaceæ.

Quercus raritanensis Berry.

Order Urticales.

Family Ulmaceæ.

Planera Knowltoniana Hollick.

Family Moraceæ.

Ficus daphnogenoides (Heer) Berry.
Ficus ovatifolia Berry.
Ficus Woolsoni Hollick.
Ficus myricoides Hollick.

Order Proteales.

Family Proteaceæ.

Persoonia spatulata Hollick.
Persoonia Lesquereuxii Knowlton.

Order Ranales.

Family Ranunculaceæ.

Dewalquea groenlandica Heer.
Dewalquea trifoliata Newb.

Family Magnoliaceæ.

Magnolia speciosa Heer.
Magnolia Hollicki Berry.
Magnolia alternans Heer.
Magnolia longipes Hollick.
Magnolia Isbergiana Heer (?).
Magnolia Lacoena Lesq.
Magnolia Newberryi Berry.
Magnolia woodbridgensis Hollick.
Magnolia Boulayana Lesq.
Liriodendron oblongifolium Newb.
Liriodendron quercifolium Newb.

Family Lauraceæ.

Sassafras acutilobum Lesq.
Sassafras progenitor Hollick.
Sassafras hastatum Newb.
Laurus plutonia Heer.
Laurophyllum nervillosum Hollick.
Laurophyllum elegans Hollick.
Laurophyllum lanceolatum Newb.
Laurophyllum angustifolium Newb.
Laurophyllum minus Newb.
Cinnamomum Newberryi Berry.

Family Menispermaceæ.

Menispermites borealis Heer.
Menispermites Wardianus Hollick.

Order Rosales.

Family Leguminosæ.

Leguminosites coronilloides Heer.
Leguminosites atanensis Heer.

Leguminosites omphalobioides Lesq.
Leguminosites raritanensis Berry.
Colutea primordialis Heer.
Liriodendropsis retusa (Heer) Hollick.
Liriodendropsis simplex Newb.
Lirodendropsis angustifolia Newb.
Cæsalpinia Cookiana Hollick.
Cæsalpinia raritanensis Berry.
Bauhinia cretacea Newb.
Bauhinia gigantea Newb.
Dalbergia apiculata Newb.
Hymenæa dakotana Lesq.
Phaseolites manhassettensis Hollick.
Prunus ? acutifolia Newb.

Order Geraniales.
Family Citraceæ.
Citrophyllum aligerum (Lesq.) Berry.

Order Sapindales.
Family Ilicaceæ.
Ilex ? elongata Newb.
Ilex amboyensis Berry.
Family Celastraceæ.
Celastrus arctica Heer.
Celastrophyllum minus Hollick.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum undulatum Newb.
Celastrophyllum decurrens Lesq.
Celastrophyllum cretaceum Lesq.
Celastrophyllum crenatum Heer.
Celastrophyllum spatulatum Newb.
Celastrophyllum grandifolium Newb.
Celastrophyllum Brittonianum Hollick.
Family Aceraceæ.
Acer amboyense Newb.

Order Rhamnales.
    Family Rhamnaceæ.
        Rhamnites minor Hollick.
    Family Vitaceæ.
        Hedera obliqua Newb.
        Hedera primordiales Sap.
        Cissites formosus Heer.
        Cissitus crispus Velen.
Order Malvales.
    Family Sterculiaceæ.
        Pterospermites obovatus (Newb.) Berry.
Order Parietales.
    Family Passifloraceæ.
        Passiflora antiqua Newb.
Order Myrtales.
    Family Myrtaceæ.
        Eucalyptus Geinitzi (Heer) Heer.
        Eucalyptus linearifolia Berry.
        Eucalyptus parvifolia Newb.
        Eucalyptus angusta Velen.
        Eucalyptus attenuata Newb.
Order Unbellales.
    Family Cornaceæ.
        Cornophyllum vetustum Newb.
    Family Araliaceæ.
        Aralia Newberryi Berry.
        Aralia quinquepartita Lesq.
        Aralia groenlandica Heer.
        Aralia rotundiloba Newb.
        Aralia patens Hollick.
        Aralia formosa Heer.
        Aralia wellingtoniana Lesq.
Order Ericales.
    Family Ericaceæ.
        Andromeda novæ-cæsareæ Hollick.
        Andromeda grandifolia Berry.
        Andromeda Cookii Berry.
        Andromeda Parlatorii Heer.

Order Primulales.

Family Myrsinaceæ.

Myrsine borealis Heer.

Myrsine oblongata Hollick.

Myrsine Gaudini (Lesq.) Berry.

Order Ebenales.

Family Ebenaceæ.

Diospyros primaeva Heer.

Diospyros raritanensis Berry.

Calycites diospyriformis Newb.

Order Gentianales.

Family Asclepiadaceæ.

Acerates amboyense Berry.

Unknown Affinities.

Calycites parvus Newb.

Carpolithus pruniformis Newb.

Carpolithus woodbridgensis Newb.

Carpolithus ovaeformis Newb.

Carpolithus hirsutus Newb.

Carpolithus floribundus Newb.

Chondrophyllum obovatum Newb.

Chondrophyllum reticulatum Hollick.

Fontainea grandifolia Newb.

Newberryana rigida (Newb.) Berry

Phyllites undulatus Newb.

Phyllites trapaformis Berry.

Tricalycites papyraceus Newb.

Tricarpellites striatus Newb.

Viburnum integrifolium Newb.

Williamsonia Smockii Newb.

Williamsonia problematica (Newb.) Ward.

PHYLUM THALLOPHYTA

Class FUNGI.

Order PYRENOMYCETES.

Genus SPHÆRITES Unger.

(Gen. et Sp., 1850, p. 37.)

SPHÆRITES RARITANENSIS sp. nov.

Description.—Viewed megascopically these remains appear as oval or circular umbilicate dots from .25 mm. to .5 mm., in diameter, with depressed margin and enlarged central portion, the latter occupying two-thirds of the total diameter.

Found in abundance on the under side of leaf fragments (sp. indet.) in the matted layers of fossil leaves from the upper Raritan at the Hylton Pits. Conclusively congeneric with the forms usually referred to this genus and very similar to *Sphærites problematicus* (Knowlt.) Knowlt., from the Dakota Group of Kansas. The latter is, however, more irregular in outline, larger in size and infests *Sterculia* which is not the host of the Raritan species. While remains of this sort are of little botanical interest to some, they nevertheless have a considerable biological significance in the evidence which they afford of the existence during the Mid-Cretaceous of fungi of this order.

Occurrence.—Hylton Pits.

Collections.—Johns Hopkins University.

Class ALGAE.

Genus CHONDRITES Sternberg.

(Fl. d. Vorw., vol. ii, 1833, p. 25.)

CHONDRITES FLEXUOSUS Newb.

Chondrites flexuosus Newb., Fl. Amboy Clays, *34, pl. 1, f. 1, 4,* 1896. Berry, Bull. N. Y. Bot. Gardens, vol. 3: 100, 1903 (?).

Description.—The remains so-named by Professor Newberry consist of rather indefinite ramifying vegetable fibers supposedly algal in their nature, but poorly defined and of uncertain biological significance. They are strictly comparable with similar remains described from abroad and so named from their resemblance to the modern genus *Chondria* Harvey of the Rhodomelaceæ.

Schimper[1] forty years ago listed eleven European species, mostly Tertiary in age. A number of additional species have been described since that time, including one from the Magothy formation[2] which is very similar to a Lower Senonian species of Westphalia. Most of these species are, however, poorly preserved, and vague in their affinities.

Occurrence.—Woodbridge, Sayreville.

Collections.—N. Y. Botanical Garden.

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[1] Pal. Vègèt. t. I, 1869, p. 154.

[2] Berry, Amer. Nat., vol. xxxvii, 1903, p. 677, fig. 9.

PHYLUM PTERIDOPHYTA.

Order FILICALES.

Family GLEICHENIACEÆ.

Genus GLEICHENIA Smith

(Mem. Ac. Turin, vol. v, 1791, p. 418.)

GLEICHENIA ZIPPEI (Corda) Heer.

Gleichenia Zippei Heer, Fl. Foss. Arct., vol. i; 79, *pl. 43, f. 4*, 1868; Ibid., vol. 3, ab. 2: 44, 90, 97, *pl. 4; 5; 6, f. 1–3; pl. 7, f. 2; pl. 25, f. 1–3; pl. 26, f. 10–13*, 1874; Ibid., vol. 4: 49, *pl. 32, f. 6, 7*, 1877; Ibid., vol. 6, ab. 2: 36, *pl. 3, f. 2*, 1882; Ibid., vol. 7: 7, 1883.
Velen, Farne böhm, Kreidef. 6, *pl. 3, f. 3–7*, 1888.
Newb., Fl. Amboy Clays, 37, *pl. 3, f. 5*, 1896 (?).
Ward, 19 Ann. Rep. U. S. Geol. Surv., pt. 2: 664, *pl. 162, f. 9*, 1899 (?).
Berry, Bull. Torrey Club, vol. 31: 67, *pl. 4, f. 6*, 1904; Ibid., vol. 33: 164, 1906.

Pecopteris Zippei Corda in Reuss, Versteinerungen, 95, *pl. 49, f. 1*, 1846.
Unger, Kreidepflanzen aus Oestreich, Sitzungsb. Acad in Wein, 1867: 8, *pl. 2, f. 1*.

Description.—"Gl. foliis bipinnatis, pinnis valde approximatis, elongatis, linearibus, parallelis, pinnatisectis, pinnulis obliquis, lanceolatis, acutiusculis, integerrimus, basi vix unitis; nervis pinnatis, nerv. secund. utrinque 3–5, inferioribus furcatis." Heer 1868.

Professor Newberry's determination of this species in the Raritan material is based upon very fragmentary specimens, although some of them have traces of the sori preserved. One specimen is figured in his flora of the Amboy Clays. These are sharply contrasted by the beautiful Gleichenia material obtained by Professor Heer from Greenland. As far as the New Jersey

material goes it corresponds exactly with the more typical material from other regions, and until specimens are collected showing adequate grounds for separation, we are justified in assuming the presence of this species in New Jersey in Raritan times. The genus *Gleichenia* was a prominent one during the Cretaceous with many characteristic species, some with a wide range. The present species, which ranges through the Greenland Cretaceous series from the Kome beds to those of Patoot, occurs also in the Lower Cretaceous of Spitzbergen and the Black Hills; the Cenomanian of Bohemia; the Senonian of Bohemia, Saxony and Bulgaria; the Magothy formation of New Jersey and Delaware; and it has recently been collected in the Upper Cretaceous of the Western Interior. It is not contained in any recent collections from the Raritan.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

GLEICHENIA GIESEKIANA Heer.

Gleichenia Giesekiana Heer, Fl. Foss, Arct., vol. 1 : 78, *pl. 43, f. 1a, 2a, 3; pl. 44, f. 2, 3,* 1868; Ibid., vol. 3, ab. *2*: 43, *pl. 3, f. 1d, 8; pl. 7, f. 1,* 1874; Ibid., vol. 6, ab. *2*: 35, *pl. 2, f. 9a, b; pl. 13, f. 4b,* 1882*;* Ibid., vol. *7*: 7, *pl. 50, f. 1–3,* 1883.

Newb., Fl. Amboy Clays, 36, *pl. 4, f. 12,* 1896.

Description.—"Gl. fronde dichotoma, bipinnatipartita, pinnis elongatis, linearibus, parallelis, pinnatipartitis, pinnulis patentibus, subindefalcatis, oblongis, apice rotundatis, obtusis, integerrimis, basi unitis, nervulis furcatis, soris biseriatis, rotundis." Heer 1868.

The presence of this species in New Jersey, like the preceding, is based upon very fragmentary specimens. It is much larger than the other Gleichenia-like fragments from the Raritan and agrees closely with Heer's species which ranged through the Greenland Cretaceous occurring in the Kome, Atane and Patoot beds. It has also been collected recently from the Upper Cretaceous of the Western United States.

Possibly the Raritan material should be correlated with the genus *Cladophlebis,* which is so abundant in the older formations of the Potomac Group, but until decisive material comes to light Professor Newberry's determination should stand.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

GLEICHENIA MICROMERA Heer.

Gleichenia micromera Heer, Fl. Foss. Arct. vol. 3, ab. 2: 55, *pl. 10, f. 14, 15,* 1874.
Newb., Fl. Amboy Clays, 36, *pl. 3, f. 6,* 1896 (?).

Description.—"Gl. fronde bipinnata, rachi tenui, pinnis valde approximatis, patentissimis, linearibus, pinnulis minutis, horizontalibus, liberis, ovatis, basi utrinque rotundatis, apice obtusis, nervis secundariis simplicibus." Heer, 1874.

Like the two preceding species this is also based on fragmentary specimens. These are of a delicate fern with narrow linear right angled pinnules of very small size which agree exactly with the type material.

This species was described originally from the Kome beds of Greenland, which are correlated with the Urgonian of Europe, but this offers no obstacle to its occurrence in the New Jersey Raritan since characteristic specimens of other species of this genus show an equal range.

Occurrence.—Sayreville, Milltown.

Collections.—N. Y. Botanical Garden.

Family CYATHEACEÆ.

Genus DICKSONIA Presl.

(Pterid., 1836, p. 135.)

DICKSONIA GROENLANDICA Heer.

Plate IV, Fig. 1.

Dicksonia groenlandica Heer, Fl. Foss. Arct., vol. 6, ab. 2: 23, *pl. 35, f. 8, 9,* 1882. Ibid., vol. 7: 2, *pl. 48, f. 1–3,* 1883.
Berry, Bull. Torrey Club, vol. 36: 245, 1909.

Dicksonia borealis Heer, loc. cit., vol. 6, ab. 2: 23, *pl. 44, f.* 2. 1882 (not *D. borealis* Heer, 1878, a very different, Jurassic species).

Anemia stricta Newb., Fl. Amboy Clays, 38, *pl. 3, f. 1, 2,* 1896.

Description.—"D. foliis bipinnatis, pinnulis erectis, oblongo-lanceolatis, basi attenuatis, integerrimis, nervis subtilissimis, nervillis angulo acuto egredientibus, erectis." Heer, 1882.

Both of Heer's types, which are here united with Newberry's species, are small fragments of ultimate pinnæ, which their author confesses are very similar, a fact well brought out by a comparison of the figured specimens. The material from Woodbridge is more ample, and as may be seen lower down on the frond the pinnules become toothed and finely pinnatifid, a feature not seen in the Greenland material. There is slight reason, however, for doubting their identity, Newberry himself pointed out that *Dicksonia borealis* of Heer was probably identical with his Amboy clay species. Although common at Woodbridge, N. J., this species has not been found elsewhere in the Coastal Plain except for a single specimen which the writer discovered recently in the Tuscaloosa formation of Alabama. It is present at both the Atane and Patoot horizons of Greenland.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family POLYPODIACEÆ.

Genus PHEGOPTERIS Presl.

(Pterid., 1836, p. 179.)

Phegopteris Grothiana Heer.

Phegopteris Grothiana Heer, Fl. Foss. Arct., vol. 7: 3, *pl. 48, f. 12, 13,* 1883.

Newb., Fl. Amboy Clays, 42, *pl. 3, f. 4,* 1896.

Description.—"P. foliis bipinnatis, pinnulis patentibus, liberis, basi æqualibus, 4 mm. latis, 20–22 mm. longis, linearibus, crenatis; nervis secundariis ramosis, nervillis simplicibus." Heer, 1883.

Like most of the Raritan fern-remains, those representing the present species are fragmentary and inconclusive, resembling, as far as it is possible to judge, Heer's type material which came from the Patoot beds of Greenland. As the latter is supposed to be of Senonian age, it is possible that the New Jersey forms belong to a different species of this genus, but of this it is impossible to form a satisfactory conclusion. It is to be hoped that additional and better material will some day be collected which will definitely settle the question.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus ASPLENIUM Linnè.

(Sp. Pl., 1753, p. 1078.)

ASPLENIUM DICKSONIANUM Heer.

Plate V, Figs. 3, 4.

Asplenium Dicksonianum Heer, Fl. Foss. Arct., vol. 3, ab. 2: 31, *pl. 1, f. 1–5*, 1874; Ibid., vol. 6, ab. 2: 3, 33, *pl. 2, f. 2; pl. 32, f. 1–8*, 1882.

Dawson, Trans. Roy. Soc. Can., vol. 1, sec. 4: 11, 1883; Ibid., vol. 3, sec. 4: 5, *pl. 3, f. 1*, 1885; Ibid., vol. 10, sec. 4: 91, 1892; Ann. Rept. Can. Geol. Surv., N. S., vol. 1: 76, 1886.

Lesq., Fl. Dakota Group, *24, pl. 1, f. 1*, 1892.

Newb., Fl. Amboy Clays, 39, *pl. 1, f. 6, 7; pl. 2, f. 1–8; pl. 3, f. 3*, 1896.

Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2: 704, *pl. 170, f. 1*, 1899; Journ. Geol. vol. 2: 259, 261, 1894.

Fontaine in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2: 664, *pl. 162, f. 6–8*, 1899 (non Font. 1888).

Kurtz, Contrib. Palæophyt. Argentina III, Rev. Museo La Plata, vol. 10: 49 (1899) 1902.

Description.—"A. foliis triplicato-pinnatis, stipite firmo, rigido; pinnis primariis secundariisque ovato-lanceolatis, pinnulis anguste lanceolatis, inferioribus acute serratis, superioribus integerrimis, acutis." Heer, 1874.

This species was described originally by Heer from the Kome beds of Greenland and was subsequently identified by the same author from the much later Atane beds; Dawson reports it from a number of localities in the Kootanie of British Columbia, and Fontaine and Ward describe it from the Lower Cretaceous of the Black Hills. It is also reported by both Lesquereux and Ward from the Dakota Group and by Kurtz from Argentina. It seems very doubtful if these can all be the same plant, and the gelogical range alone suggests that the earlier and the later forms may be distinct. The Lower Cretaceous forms certainly suggest a relationship with those wide-spread types of sterile fronds variously identified as *Thryrsopteris* or *Onychiopsis,* while those from the Upper Cretáceous suggest *Anemia* rather than *Asplenium.* However, in the absence of representative material from the different horizons, it seems unwise to attempt any segregation at the present time.

The specimens from the Raritan are abundant at the Woodbridge horizon and many excellent figures are given by Newberry in his Flora of the Amboy Clays.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

Asplenium Foersteri Deb. & Ettings.

Plate V, Figs. 1, 2.

Asplenium Foersteri Deb. & Ettings, Urwelt. Acrobry. v. Aachen, 13, *pl. 2, f. 4–7,* 11, 1859.

Schimp., Pal. Vègèt., I: 658, 1869.

Heer, Fl. Foss. Arct., vol. 3, ab. 2: 93, *pl. 26, f. 1,* 1874; Ibid., vol. 7: 174, 266, 1883.

Velenovsky, Farne böhm Kreidef, 15, *pl. 1, f. 14,* 1888; Květena ceséło cenomanu, 48, 52, 60, 1889.

Newb., Fl. Amboy Clays, 41, *pl. 4, f. 1–11,* 1896.

Zeiller, Ann. Mines, March, 1905, p. 7, *pl. 7, f. 1.*

Description.—"A. fronde pinnata (v. pluries pinnata?), pinnis regulariter alternis, confertis, subdecurrentibus, subangulo

50° circiter arrectis, late frondosis, lineari-lanceolatis, lobato-dentatis vel basi pinnatifidis vel pinnati-partitis, laciniis ovato-obtusis apice denticulatis, vel ovato-acuminatis, sub-alternis, confertis, terminalibus longe lineari-lanceolatis, angustissimis, remote dentatis; nervis venisque strictis, arrectis, simplicibus vel sæpius furcatis, creberrimis." Debey and Ettings, 1859.

A considerable number of specimens, which Professor Newberry identified as this species, were found in the Raritan. They are more complete than the material so identified from elsewhere and show several minor differences. The lower pinnæ of the former are widely separated, opposite or sub-opposite, and markedly decurrent as well as unsymmetrical. Higher up, however, the pinnæ become closer until they finally unite, passing from notched to simple lobes, and these latter are very similar to the type of the species. The texture is coriaceous and the venation fine and largely obsolete.

The species is recorded from the Cenomanian of Greenland and Bohemia and the Senonian of Prussia and Bulgaria. The remains referred to this species by Lesquereux from the much older horizon at Cape Lisbourne, Alaska, are found to be identical with *Cladophlebis Huttoni* (Dunk.) Font.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Asplenium raritanense Berry.

Asplenium raritanense Berry, Bull. Torrey Club, vol. 36:246, *pl. 18, fig. 1*, 1909.

Description.—Frond or pinnæ unknown. Pinnules small 1.33 cm. long by 10 mm. in greatest breadth, ovate in outline with narrow somewhat straight-sided base, palmately divided into 1 terminal and 2 pairs of lateral, rounded, not deeply parted, lobes. Margin entire at base and in sinuses, sharply toothed on the lobes. Venation flabellate, about 7 veins enter the base of the pinnule, these soon fork dichotomously, the ultimate divisions terminating in the marginal teeth.

Fig. 4.—Asplenium raritanense Berry. Hylton Pits, Pensauken Creek.

This species, which is quite unlike anything heretofore known from the Raritan, is unfortunately based on the single tiny pinnule figured. The general form and habit remain unknown. It is markedly distinct from any described fossil species known to the writer, although showing some points of resemblance to various arctic species referred to this genus by Professor Heer. Since the chances of more representative material being found are remote, it has seemed best to describe it under the above name.

Occurrence.—Hylton Pits.

Collection.—Johns Hopkins University.

Asplenium jerseyensis sp. nov.

Description.—Frond compound (?). Pinnæ linear in outline, made up of alternate triangular somewhat falcate pinnules. The latter have acute tips and entire margins; they are attached by their entire base. Rachis very stout. Texture extremely thick and coriaceous.

Midrib stout, branching from the rachis in the proximal half of the pinnule, giving off alternate, apparently forked secondaries on either side.

This species is based upon the incomplete specimen figured and its counterpart. In appearance it is exactly like so many Cretaceous fern-fragments which are referred to the genus *Gleichenia*, as for example *Gleichenia gracilis* Heer or *Gleichenia acutiloba* Heer, it being particularly close to the Bohemian re-

mains referred to the latter species by Velenovsky.[1] The New Jersey species is clearly not a *Gleichenia,* however, since the tiny fragment preserved is part of a fruiting plant, and while the preservation is too poor for discerning the details, it is sufficiently

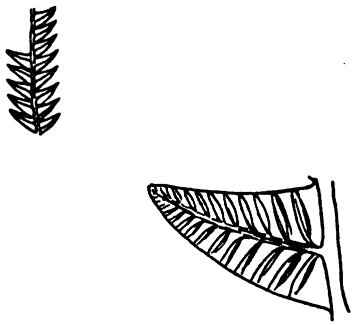

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Fig. 5.—Asplenium jerseyensis sp. nov. Milltown, N. J.

good to show the remains of oblong-lanceolate sori on the lateral veins of the pinnules exactly as in many species of *Asplenium,* to which genus it is consequently referred. It differs from any previously described Cretaceous forms, although a similar but larger Asplenium in fruit has been collected by the writer from the Magothy formation at Grove Point, Maryland.

Occurrence.—Milltown.

Collection.—U. S. National Museum.

Family OPHIOGLOSSACEÆ.

Genus OPHIOGLOSSUM Linné.

(Sp. Pl., 1753, p. 1062.)

OPHIOGLOSSUM GRANULATUM Heer.

Ophioglossum granulatum Heer, Fl. Foss. Arct., vol. 7: 8, *pl. 57, f. 8, 9,* 1883; Newb., Fl. Amboy Clays, 43, *pl. 9, f. 11–13,* 1896.

[1] Velen. Die Farne der Böhm, Kreideform, p. 7, pl. iii, figs. 8-10, 1888.

Description.—"O. spica fertili elongata, sporangiis distichis, ovalibus granulatis, 1½ mm. longis." Heer, 1883.

This species described originally by Professor Heer from the Patoot beds of Greenland and compared with the fertile frond of *Ophioglossum vulgatum* has been found in considerable numbers in the Raritan clays, although Professor Newberry failed to indicate the exact localities. There can be no question of the identity of the Greenland and the New Jersey material. The reference to *Ophioglossum* is not so conclusive, and many students will echo Newberry's supposition that these remains are those of staminate cones of some species of conifer. Since no new light can be shed on their systematic position, they are retained where Heer and Newberry placed them.

Occurrence.—Locality unknown.

PHYLUM SPERMATOPHYTA.

Class GYMNOSPERMAE.

Order CYCADALES.

Genus PODOZAMITES F. Braun.

(In Münster, Beitrage, Vol. II, 1843, p. 28.)

PODOZAMITES MARGINATUS Heer.

Podozamites marginatus Heer, Fl. Foss. Arct., vol. 6, ab. 2: 43, *pl. 16, f. 10,* 1882.
Newberry, Fl. Amboy Clays, 44, *pl. 13, f. 5, 6,* 1896.
Berry, Bull. N. Y. Bot. Garden, vol. 3: 99, *pl. 46, f. 1–3,* 1903.

Description.—"Z. foliis magnis, foliolis elongato-lanceolatis, 23 mm. latis, apicem versus sensim angustatis, multinerviis, late et fortiter marginatis." Heer, 1882.

Leaflets large, 15 cm. to 20 cm. in length by 2.3 cm. to 4 cm. in breadth, lanceolate in outline, somewhat falcate. Apex obtusely pointed. Proximally somewhat abruptly narrowed to an apparently thickened base. Veins numerous, close, fine, parallel.

Remains of a large parallel-veined leaf, apparently a leaflet of *Podozamites,* are not uncommon in the Raritan deposits, although unfortunately they are usually fragmentary. They seem to be identical with the type material of this species described by Heer from the Atane beds of Greenland, which ranges southwards along the Atlantic coastal plain as far as Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

PODOZAMITES KNOWLTONI Berry.

Podozamites angustifolius (Eichw.) Schimper, Pal. Végét. vol. 2: 160, 1872 (non Schenk, 1868).
Lesq. Cret. & Tert. Fl., 28, 1884; Fl. Dakota Group, 27, *pl. 1, f. 4,* 1892.

Newb., Fl. Amboy Clays, 44. *pl. 13, f. 1, 3, 4,* 1896 (non f. 2).

Zamites angustifolius Eichwald, Lethæa rossica, vol. 2: 39, *pl. 2, f 7.*

Podozamites Knowltoni Berry, Bull. Torrey Club, vol. 36: 247, 1909.

Description.—"Foliolis elongato-lineali-lanceolatis, centim. 6 circiter longis, infra medium millim, 5 latis, basimversus margine inferiore subitius angustatis quam superiore, decurrentibus, sat approximitis et erecto-patentibus." Schimper, 1870.

In 1870 Schimper referred the *Zamites angustifolius* of Eichwald to this genus, overlooking the fact that Schenk four years earlier had described and named a species of *Podozamites angustifolius.* The natural impulse would be to call this *P. Eichwaldi,* but Eichwald has already had a species of *Podozamites* named for him in consequence of which the above name is proposed in honor of Dr. F. H. Knowlton of the U. S. National Museum. This species has a wide range, both geological and geographical. It is common in the Jurassic of high latitudes in Russia, Siberia, Bornholm, and Spitzbergen, and in the Upper Cretaceous indistinguishable remains are widely distributed in America. The abundant Raritan remains are long-lanceolate, 5 cm. to 15 cm. in length by 6 cm. to 1.2 cm. in width, the base narrowed to a short petiole, the summit being long pointed and the venation fine. They are similar to the leaflets of *Podozamites lanceolatus,* but are usually longer, narrower and more flexuous in outline.

All of the Raritan species of *Podozamites,* in common with those from other localities and horizons, which are based on detached leaflets, are extremely unsatisfactory from the standpoint of the botanist, since their true position remains doubtful. It has been suggested by more than one author that some of these remains ascribed to *Podozamites* were not cycad leaflets at all, but were probably referable to the Araucarieæ or some other sub-family of the Coniferales, but the available facts do not warrant any definite conclusion at the present time, and until positive

information is at hand it would be unwise to alter the present nomenclature.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

PODOZAMITES LANCEOLATUS (L. & H.) F. Braun.

Zamia lanceolata L. & H., Foss. Fl. vol. 3, *pl. 193*, 1836.

Zamites lanceolatus F. Braun., Verzeich. Kreis.-Nat.-Samml. Bayreuth Petrefact., 100, 1840.

Podozamites lanceolatus F. Braun in Münster, Beitr. Petrefactenkunde, vol. 2, pt. 6: 33, 1843.

Schimper, Pal. Végét., vol. 2: 160, 1870.

Velenovsky, Gymn. Böhm. Kreidef., 11, *pl. 2, f. 11–19, 24*, 1885.

Dawson, Trans. Roy. Soc. Can., vol. 3, sec. 4: 6, *pl. 1, f. 3*, 1886.

Lesq. Fl. Dakota Group, 28, *pl. 1, f. 5, 6*, 1892.

Penhallow, Summary Geol. Surv. Can., 1904: 9, 1905.

Fontaine in Ward, Mon. U. S. Geol. Surv., vol. 48: 110, *pl. 24, f. 17–20*, 1906.

Knowlton, Smith. Misc. Coll., vol. 4, pt. 1: 120, *pl. 14, f. 4*, 1907.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 35, *pl. 2, f. 1*, 1907.

Podozamites proximans Conrad, Amer. Jour. Sci., (II) vol. 47: 361, tf. 1869.

Podozamites angustifolius Newb., Fl. Amboy Clays, 44, *pl. 13, f. 2*, 1896 (non f. 1, 3, 4).

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 410, *pl. 71, f. 8*, 1904.

Description.—"Pinnis distantibus, alternis oppositisve, elongatis, basi sensim angustatis, inferioribus lanceolato-linearibus, superioribus elongato-ellipticis; nervis crebris." Schimper, 1870.

This is a species of great vertical range, being recorded from the Jurassic upward to the Upper Cretaceous. The lateral range is equally great, embracing two continents, North America and

Europe. It is quite probable that it is composite, but no certain grounds for segregation are apparent.

While some students may doubt the wisdom of correlating these Upper Cretaceous forms with a species which is essentially a Jurassic type, specific differention founded merely upon stratigraphy has gone astray so often that in cases like the present synthesis may well precede analysis, and it might be added that this was the view taken by Hollick[1] with reference to material from Glen Cove, Long Island, and by Velenovsky[2] in studying the Cenomanian flora of Bohemia.

This was the first fossil plant from the Raritan which received a specific name, having been described and figured by Conrad in 1869, who, however, failed to perceive its identity with the *Podozamites lanceolatus* of European authors.

As found in the Raritan the leaflets are detached, lanceolate in outline, pointed at both ends and widest near the base. Length about 7 cm., and width about 8 mm.

Occurrence.—Woodbridge, along South River (Conrad).

Collections.—N. Y. Botanical Garden.

PODOZAMITES ACUMINATUS Hollick.

Podozamites acuminatus Hollick in Newb., Fl. Amboy Clays, 45, *pl. 13, f. 7,* 1896.

Description.—Leaflets long, about 16 cm. to 18 cm. in length, 1.1 cm. in width, with a long slender acuminate tip. Venation open. Veins eleven in number, about 1 mm. apart.

This imperfectly characterized species was based upon a single fragmentary specimen collected at the Woodbridge horizon, and as no additional specimens have come to light, its status remains doubtful. It is hardly worthy of a place in the literature, but since it is already established it has to be considered. It is clearly different from the other remains of *Podozamites* hitherto dis-

[1] Hollick, Mon. U. S. Geol. Surv., vol. L, 1907, p. 35.

[2] Velenovsky, Gymn. Böhm. Kreidef., 11 pl. 2, f. 11-19, 24, 1885.

covered in the Raritan formation, and these differences may well be of specific value. It is to be hoped that additional and more representative material may eventually be collected.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus MICROZAMIA Corda.

(In Reuss. Verst. Böhm, Kreidef., ab. II, 1846, p. 85.)

MICROZAMIA GIBBA (Reuss) Corda.

Conites gibbus Reuss, Geognostische Skizzen, vol. 2: 169.
Zamiostrobus gibbus Schimp. Pal. Végét, vol. 2: 202, 1870.
Microzamia gibba Corda in Reuss. Verst. Böhm, Kreidef. ab. 2: 85, 1846.
Velen., Gym. Böhm, Kreidef., 6, *pl. 3, f. 5–16; pl. 4, f. 6; pl. 5, f. 8,* 1885.
Newb., Fl. Amboy Clays, 45, *pl. 12, f. 6. 7,* 1896.

Description.—Judging from Corda's original drawing, which is preserved in the library of the N. Y. Botanical Garden, and from the numerous figures published by Velenovsky, the European specimens, which come from several Cretaceous localities in Bohemia (Lann, Vyserovic, Weissenberg, etc.), are correctly identified as cycadaceous fructifications. With regard to Newberry's specimens no such certainty can be entertained. The type material cannot be found at the N. Y. Botanical Garden, and what specimens of this species are in the collections of that institution are in a very poor state of preservation. Newberry's figures are only remotely like those of the European material, and his determination must be considered very doubtful, although there are no apriori reasons why this form should not occur in the Raritan, since cycad foliage is rather common, and the New Jersey and Bohemian Cretaceous have quite a number of identical species.

A fact tending to throw still more doubt on Newberry's idenfication was observed some years ago while collecting from the Magothy formation at Cliffwood bluff, New Jersey. At this point the clays are full of pyritized cones which are identical

with those described from Quedlinburg, Saxony, by Heer as *Geinitzia formosa* and by Newberry and the writer as *Sequoia gracillima*. These cones are not always pyritized, but are sometimes simply lignified and flattened in the clays, and in the latter state they are distinguishable with difficulty from the specimens labelled *Microzamia gibba* in the collections of the N. Y. Botanical Garden. Foliage seemingly correctly identified as that of *Geinitzia formosa* has been recorded from Woodbridge by Newberry and from Cliffwood Bluff by the writer, so that the presumption is strong that Newberry's *Microzamia gibba* really is *Geinitzia formosa*. Because I have been unable to find Newberry's types or to settle the question beyond reasonable doubt, and influenced somewhat by the fact that the cones called *Geinitzia formosa* or *Sequoia gracillima* are so very abundant in, and characteristic of, the overlying Magothy formation, I have not thought it wise to make any change in name at the present time.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CYCADINOCARPUS Schimper.

(Pal. Végét., vol. II, 1870, p. 208.)

CYCADINOCARPUS CIRCULARIS Newb.

Cycadinocarpus circularis Newb., Fl. Amboy Clays, 46, *pl. 46, f. 1–4*, 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Description.—Discoid fruits almost circular in outline from 6 mm. to 12 mm. in diameter, sometimes slightly emarginate on one side at the point which Professor Newberry believed to be the point of attachment, but which is probably the distal micropylar extremity. As usually preserved the impression shows two concentric circles 1 to 2 mm. apart, the inner representing the outline of the inner seed coat and the outer layer the slightly fleshy external coat.

These fruits always occur detached and are present in considerable abundance at Woodbridge, but have not been detected from other localities in the Raritan. Similar remains are recorded from the Tuscaloosa formation of Alabama, and they are also present in the Bladen formation of North Carolina. As their name indicates they are assumed to represent the fruit of some contemporaneous species of cycad.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order CONIFERALES.

Family PINACEÆ.

Subfamily ARAUCARIEÆ.

Genus DAMMARA Lam.

(Encyc. II, 1786, p. 259.)

DAMMARA BOREALIS Heer.

Dammara borealis Heer, Fl. Foss. Arct., vol. 6, ab. 2: 54, *pl. 37, f. 5*, 1882.
Velen, Květena českého cenomanu., *7, pl. 1, f. 28, 29*, 1889.
Hollick, Trans. N. Y. Acad. Sci., vol. 12: 31, *pl. 1, f. 17*, 1892; Bull. N. Y. Bot. Garden, vol. 2: 402, *pl. 41, f. 6*, 1902; U. S. Geol. Survey, Mon. 50: 37, *pl 2, f. 2–11* (pars), *12–26* (pars), *27a*, 1907.
Newb., Fl. Amboy Clays, 46, *pl. 10, f. 8*, 1896.
—— Hitchcock, Final Rept. Geol. Mass., vol 2: 430, *pl. 19, f. 4, 5*, 1841.

Description.—"D. strobilorum squamis coriaceis, radiatim sulcatis, 22 mm. latis, apice obtuse rotundatis, apiculatis, basi attenuatis." Heer, 1882.

Scale-like organisms from 1 cm. to 2 cm. or possibly more in length, rounded distally and showing in some specimens a but slightly emphasized apiculate point. Greatly expanded laterally in the upper part to a breadth reaching 2.5 cm., abruptly contracted at about the middle to a cuneate or straight-margined

flat stalk about 5 mm. in width, with numerous resin-canals approximately parallel with the lateral margins and dying out proximad, filled with an amber-like substance.

Remains of this species were described and figured by Hitchcock in his account of the organic remains found at Gay Head, Marthas Vineyard, as long ago as 1841. He did not name them, but remarks: "It seems to me very obvious that these remains must be the seed vessels of some coniferous plants." In 1882 Professor Heer found similar forms in the material from the west coast of Greenland and named and described them, as well as two other very similar forms, and definitely recognized their relation to *Dammara*. Subsequently they have been recorded from the European Cenomanian by Velenovsky, Krasser and Beyer, from the Raritan formation by Professor Newberry, from Long Island and Staten Island by Hollick. Unpublished work of the writer will extend their range southward to North Carolina and Alabama. They are abundant in the Raritan formation at Woodbridge and occur at the South Amboy horizon immediately across the Arthur Kill on Staten Island.

Similar remains have been considered by Heer, White, Krasser and others as representing the fruits of *Eucalyptus*, but it seems obvious that their relations are definitely with the Araucarian conifers.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus BRACHYPHYLLUM Brogn.

(Prodrome, 1828, p. 109.)

BRACHYPHYLLUM MACROCARPUM Newb.

Plate VII.

Thuites crassus Lesq., Cret. & Tert. Fl., 32, 1884.

Brachyphyllum crassum Lesq., Proc. U. S. Nat. Mus., vol. 10: 34, 1887; Fl. Dakota Group, 32, *pl. 2, f. 5,* 1892 (non Tenison-Woods, 1883).

Newb., Fl. Amboy Clays, 51, *pl. 7, f. 1–7,* 1896.

Brachyphyllum sp., Knowlton, Bull. Geol. Soc., Am. vol. 8: 137, 140, 1897.

Brachyphyllum macrocarpum, Newb., MSS name mentioned in footnote, p. 51, Fl. Amboy Clays, 1896.

Knowlton, Bull. U. S. Geol. Surv., No. 163: 29, *pl. 4, f. 5, 6,* 1900.

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 406, *pl. 70, f. 4, 5,* 1904; U. S. Geol. Surv. Mon. 50: 44, *pl. 3, f. 9, 10,* 1907.

Berry, Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906; Bull. Torrey Club, vol. 32: 44, *pl. 2, f. 9,* 1905; Ibid., vol. 33: 168, *pl. 9,* 1906.

Hollick and Jeffrey, Amer. Nat., vol. 40: 200, 1906.

? *Moriconia cyclotoxon* Deb. & Ett., Heer, Fl. Foss. Arct., vol. 7, *pl. 54, f. 1c,* 1883 (non Heer's other figures).

Description.—Stout twigs, pinnately branched, covered with large, thick, rhomboidal, squamate, densely crowded, appressed leaves attached by practically their whole ventral surface. Phyllotaxy spiral. Leaf-surface striated, the striæ converging toward the obtuse apex. Cones not positively determined.

Brachyphyllum is chiefly an older Mesozoic type, but it remains abundant through the Lower Cretaceous, two species having been described from the Potomac Group of Maryland and Virginia. It is a waning type in the Upper Cretaceous, represented by but a single species, the one under discussion, which persists as high as the Senonian. It is widely distributed, and is recorded from Long Island, Staten Island, New Jersey and Delaware, in the east, and from the Dakota Group, of Kansas, and the Montana Group of Wyoming, in the west.[1] It is probably represented in the Patoot beds of Greenland, by the material which Heer erroneously refers (loc. cit.) to *Moriconia.* While it is not recorded from Europe, Velenovsky has described remains from the Cenomanian of Bohemia, which appear to be identical with the American representatives, referring them to the Jurassic genus *Echinostrobus* of Schimper.[2] Hollick and Jeffrey have recently

[1] It has also been collected by the writer in North Carolina, South Carolina, Georgia and Alabama.

[2] Velen., Gym. Böhm. Kreidef. 1885, p. 16, pl. vi, figs. 3, 6–8; Kvetena ceskeho cenomanu, 1889, p. 9, pl. i, figs. 11–19; pl. ii, figs. 1, 2.

shown, with the aid of specimens from Staten Island, with structure preserved (loc. cit.), that this species is referable to the Araucarieæ.

This species is extremely common in the upper Raritan beds at South Amboy and their eastward extension on Staten Island, but has not been collected from any of the plant-bearing horizons of the lower Raritan. Prof. Newberry describes (loc. cit.) large cones which he found associated with these twigs and which he thought were related to them, although this seems improbable. The cones are poorly preserved and their affinities cannot be made out. They are very different from previously described cones of *Brachyphyllum*, and the work of Hollick and Jeffrey (loc. cit.) would seem to indicate that the present species had small cones. The cones described by Prof. Newberry, while they are here retained in the synonym of this species, are comparable to the abundant cones from the older Potomac of Maryland, which are referred to the form genus *Abietites*.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Sub-Family Cupresseæ.

Genus THUJA Linné.

(Sp. Pl., 1753, p. 1002.)

Thuja cretacea (Heer) Newb.

Libocedrus cretacea Heer, Fl. Foss. Arct., vol. 6, ab. 2: 49, *pl. 29, f. 1–3; pl. 43, f. 1d*, 1882.

Thuja cretacea Newb., Fl. Amboy Clays, 53, *pl. 10, f. 1, 1a*, 1896.

Knowlton, Bull. U. S. Geol. Surv., No. 257: 133, *pl. 16, f. 3a*, 1905.

Berry, Bull. Torrey Club, vol. 33: 169, 1906.

Description.—"L. ramulis gracilibus, oppositis, compressis, foliis quadrifariam imbricatis, lateralibus basi connatis, appressis

breviter subacuminatis, facialibus rhombeis, minutis, dorso argute carinatis." Heer, 1882.

This species was described originally from the Atane beds of Greenland, as a species of *Libocedrus*. When Prof. Newberry came to study the abundant remains from the upper Raritan he changed the generic reference to *Thuja* on what appears to be good evidence. Similar remains have been identified by Knowlton, from the Judith River beds of Montana, and the writer has noted identical remains in considerable abundance in the Magothy formation of Delaware and Maryland.

This is another one of those species from the upper Raritan whose affinities are entirely with those of somewhat later formations, and which serve to emphasize the Cenomanian age of the formation as a whole.

The twigs are strap-shaped, with nearly parallel sides 2 mm., or slightly less in width, and with four rows of short, appressed leaves.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Genus THUITES Sternberg.

(Fl. d. Vorw., vol. 1, 1823, p. 39.)

THUITES MERIANI Heer.

Thuites Meriani Heer, Fl. Foss. Arct., vol. 3, ab. 2:73, *pl. 16, f. 17, 18,* 1873; Ibid., vol. 6, ab. 2:48, *pl. 8, f. 9–11; pl. 29, f. 20, b,* 1882.
Newb., Fl. Amboy Clays, 54, *pl. 10, f. 5,* 1896.

Description.—"Th. ramulis alternis, foliis quadrifariam imbricatis, laterlibus incurvis, acuminatis, facialibus subovatis, dorso, evidenter costatis." Heer, 1873.

Twigs with four-ranked, imbricated, somewhat incurved and appressed, ovate, pointed leaves, dorsally costate. This species was described by Heer in 1873 from the Kome beds of Greenland, although it is doubtfully distinct from *Inolepis imbricata*

genus and species novum which he describes on the previous page of Die Kreide Flora der Artischen Zone. The later specimens from the much younger Atane beds are not surely identical with the older remains, although they are much the same in general appearance. They appear to depart somewhat from a cyclic phyllotaxy toward a spiral arrangement and the leaves are more spreading and less appressed. The Raritan occurrence of this species is based upon a single specimen from an unknown New Jersey locality and no additional remains have ever been discovered either in New Jersey or in more or less synchronous horizons elsewhere. While this specimen presents no evident differences when compared with Heer's figures of this species, it is very doubtfully related to the original material from the Kome beds.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus JUNIPERUS Linné.

(Sp. Pl., 1753, p. 1038.)

JUNIPERUS HYPNOIDES Heer.

Juniperus hypnoides Heer, Fl. Foss. Arct., vol. 6, ab. 2: 47, *pl. 44, f. 3; pl. 46, f. 18,* 1882.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 22, *pl. 1, f. 1,* 1892; Bull. N. Y. Bot. Garden, vol. 2: 403, *pl. 41, f. 7, 7a,* 1902; U. S. Geol. Surv. Mon. 50: 46, *pl. 2, f. 26* (pars), *27b, 28; pl. 3, f. 12–13a,* 1907.

Berry, Bull. Torrey Club, vol. 33: 168, 1906; Ann. Rept. State Geol. (N. J.) for 1905: 139, 1906.

Juniperus macilenta Heer, Newb., Fl. Amboy Clays, 54, *pl. 10, f. 7,* 1896.

Description.—"J. multiramosa, ramulis tenuissimis, congestis, foliis oppositis, falcatis, apice acuminatis, uninerviis, 1 mm. longis." Heer, 1882.

This conifer, which is a common one in the Raritan, was referred by Professor Newberry to *Juniperis macilenta* Heer,

although if the two species are to be kept separate, a not altogether certain proposition, it is clearly more closely allied to *Juniperus hypnoides* under which Hollick has already placed it (loc. cit., 1907). Professor Newberry describes its association at Woodbridge with *Dammara* scales and was evidently of the opinion that the one was the fruit of the other. Material in the New York Botanical Garden shows this association, which is probably, however, purely a mechanical one. The type material came from the Atane beds of Greenland, and additional remains are also abundant in the Raritan of Kreischerville, Staten Island, and in the Magothy formation of Martha's Vineyard, New Jersey and Delaware.

Occurrence.—Perth Amboy, Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus MORICONIA Deb. and Ett.

Moriconia cyclotoxon Deb. and Ett.

(Urwelt. Acrobry. v. Aachen, 1859, p. 59.)

Plate VIII, Figs. 3-6.

Moriconia cyclotoxon Deb. & Ett., Urwelt. Acrobry. v. Aachen, 59, *pl. 7, f. 23-27,* 1859.

Heer, Fl. Foss. Arct., vol. 6, ab. 2: 49, *pl. 33, f. 1-9b,* 1882; Ibid. vol. 7: 11, *pl. 53, f. 10; pl. 54,* 1883.

Newb., Fl. Amboy Clays, 55, *pl. 10, f. 11-21,* 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 57, *pl. 3, f. 10,* 1898; Ibid., 418, *pl. 37, f. 8.* U. S. Geol. Surv. Mon., 50: 46, *pl. 3, f. 16, 17,* 1907.

Pecopteris kudlisetensis Heer, loc. cit., vol. 3, ab. 2: 97, *pl. 26, f. 18,* 1874.

Description.—"M. fronde pinnata, pinnis longe petiolatis, pinnatifidis v. pinnatipartitis laciniis ovato-oblongis, integerrimis, apice obtusis, infinis in petiolum late decurrentibus, terminali cæteris parum longiore stricta, margine undulata, lateralibus oppositis patentibus v. arrecto patentibus; rhachi mediana crassa." Deb. and Ett., 1859.

Twigs, evidently deciduous, thin and flat, spreading in one plane, with pinnately arranged, symmetrical, opposite branches which are covered with thin closely appressed semicircular cyclic leaves, the outlines of which give to the fossil specimens that peculiar geometrical pattern, which once seen is thereafter unmistakable. Professor Heer placed it among the Cupressieæ because of its resemblance to *Libocedrus*, and while the fruit remains unknown, even in the very abundant material from South Carolina, there seems to be no valid ground for questioning this relationship. When only the outlines of the twigs are preserved the fossils have a very fern-like appearance, which served to mislead the original describers.

This exceedingly graceful and interesting conifer was originally described as a fern from the Prussian Senonian. Abundant and better material subsequently collected from Greenland enabled Professor Heer to determine its true nature. It is abundant in the upper Raritan at South Amboy, but does not occur elsewhere in that formation.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Genus WIDDRINGTONITES Endl.

(Synop. Conif., 1847, p. 271.)

WIDDRINGTONITES REICHII (Ettings.) Heer.

Plate VIII, Figs. 1, 2.

Frenelites Reichii Ett., Kreidefl. v. Niedersch, 12, *pl. 1, f. 10 a–c,* 1867.

Widdringtonites Reichii Heer, Fl. Foss. Arct., Vol. 6, ab. 2: 51, *pl. 28, f. 5,* 1882, Ibid., vol. 7: 13, *pl. 52, f. 4, 5,* 1883.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 57, *pl. 8, f. 1, 5,* 1896.
Berry, Bull. Torrey Club, Vol. 33: 169, 1906; Ann. Rept. State Geol. (N. J.) for 1905; 138, 1906.
Hollick, U. S. Geol. Surv. Mon. 50: 44, *pl. 4, f. 6–8,* 1907.

Widdringtonia Reichii (Ettings.) Velen. Gym. Böhm. Kreidef., 27, *pl. 8, f. 4–6; pl. 10, f. 1, 11, 12,* 1885; Sitzs. k. Böhm. Gesell. Wiss. 1886; 639 (6) *pl. 1, f. 14–16,* 1887.

Krasser, Beitr. Paläont. Ost-Ung. und Orients, Bd. 10: 126 (14) *pl. 14 (4), f. 6; pl. 17 (7), f. 4, 7, 8,* 1896.

Description.—"F. ramis suberectis fastigiatis, ramulis filiformibus confertis, foliis adpressis e basi ovata subulatis, strobilis axillaribus duplo longioribus quam latis." Ettings. 1867.

Medium-sized branches with more or less crowded, slender, elongated, fastigiate twigs, bearing reduced ovate-subulate leaves, spirally arranged. The cones are small oval bodies 5 mm. to 12 mm. long, by 3 mm. to 7 mm. in diameter, usually poorly preserved, said by Ettingshausen to be axillary in position, but evidently often terminal as evinced by some of the Raritan material as well as by some of the better preserved cones from the Cenomanion of Bohemia and Moravia. The latter material clearly shows that the cones consisted of four scales. This would ally it with either the subgenus *Widdringtonia* of the genus *Callitris* Vent., to which Eichler in his treatment of the living species in Engler and Prantl (1887) refers Endlicher's genus, or to the subgenus *Eucallitris* Brongn., which also is characterized by four cone-scales. The latter has a single living species of northern Africa and the former has three or four species of southern Africa and Madagascar. The propriety of Eichler's classification may well be questioned, and in any event paleobotanists must necessarily prefer the older segregation of *Frenela* and *Widdringtonia* and their respective form-genera.

There seems to be but little doubt that the present species should be referred to *Widdringtonia,* as Velenovsky and Krasser have done, but as the term *Widdringtonites* is equally indicative of its true affinity, little is to be gained by making the proposed change.

This species, which is probably the most common conifer of the Raritan formation, was described originally by Ettingshausen from the Cenomanian of Niederschœna, in Saxony, as a

species of *Frenelites*. When Heer discovered it in the Greenland material, where it has been collected from both the Atane and the Patoot beds, he transferred it to the present genus. It has subsequently been reported from the Cenomanian of Bohemia and Moravia, from the Magothy formation at numerous localities and from the southern New England islands. It has also been reported from the Tuscaloosa formation of Alabama, where it is abundant at a number of localities. Heer made *Glyptostrobus gracillinus* Lesq., of the Dakota Group, a synonym of this species, and he has been followed by many subsequent authors. As this relation is not definitely established I have not included Lesquereux's form in the foregoing synonomy, although I think they may eventually prove to be identical.

Widdringtonites Reichii is closely allied, if not identical, with a common conifer of the Patapsco formation of Maryland and Virginia, which is to be described shortly as *Widdringtonites ramosus*, being based upon *Taxodium ramosum* and various other species of Professor Fontaine's Flora of the Potomac Group. Staminate cones of the former are well shown in the Raritan specimen figured by Newberry on pl. 8, fig. 3 (loc. cit.), and similar specimens are common in the Bohemian material.

Occurrence.—Milltown, Sayreville, Woodbridge, Hylton Pits, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Widdringtonites subtilis Heer.

Widdringtonites subtilis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 101, *pl. 28, f. 1, b,* 1874; Ibid., vol. 6, ab. 2, *pl. 7, f. 13, 14; pl. 28, f. 4, b,* 1882.

Newb., Fl. Amboy Clays, 57, *pl. 10, f. 2–4,* 1896.

Hollick, U. S. Geol. Surv., Mon. 50: 45, *pl. 4, f. 2–5,* 1907.

Widdringtonites Reichii Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, *pl. 3, f. 8,* 1898.

Description.—"W. ramis tenuissimis, gracilibus, fastigiatis, foliis imbricatis, appressis, omnino tectis, foliis inferioribus falcatis, superioribus rectis." Heer, 1874.

This species was described from the Atane beds of Greenland by Prof. Heer in 1874. His material was, however, extremely limited. Subsequently it was found in considerable abundance in the Raritan formation, and still more recently Hollick has recorded it from Marthas Vineyard and Block Island. It may be questioned if some of the coniferous material described by Velenovsky from the Bohemian Cretaceous under other names should not be compared with the present form. It is even more slender than the preceding species, with much shorter twigs, which have the appearance of having been somewhat lax in habit; the leaves are more close-set and appressed, narrowly lanceolate, straight and scale-like; they are said by Heer to be somewhat spread and falcate proximad, but this feature has not been observed in any of the Raritan material.

Newberry mentions a vague cone about 1 cm. in diameter as included in the Raritan material. The writer has not seen this specimen, but has found a number of poorly preserved cones among the abundant remains of this species in the Cretaceous beds of South Carolina. Attached cones are common in the lower part of the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Genus FRENELOPSIS Schenk.

(Palaeont., vol. XIX, 1869, p. 13.)

Frenelopsis Hoheneggeri (Ett.) Schenk.

Thuites Hoheneggeri Ett., Abh. kk. geol. Reichs. 1 ab. 3, No. 2:26, *pl. 1, f. 6, 7*, 1852.

Frenelopsis Hoheneggeri Schenk, Palæont., vol. 19, hft. 1:13, *pl. 4, f. 5–7; pl. 5, f. 1, 2; pl. 6, f. 1–6; pl. 7, f. 1*, 1869.

Heer, Fl. Foss. Arct., vol. 3, ab. 2:73, *pl. 18, f. 5–8*, 1874; Ibid., vol. 6, ab. 1:7, *pl. 2, f. 1–3*, 1880; Ibid., ab. 2:16, 1882.

Font., Proc. U. S. Nat. Museum, vol. 16:275, *pl. 42, f. 4 a*, 1893.

Newb., Fl. Amboy Clays, 58, *pl. 12, f. 4, 5*, 1896.

Berry, Bull. Torrey Club, vol. 31:71, *pl. 4, f. 9, 10*, 1904.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:410, *pl. 72, f. 1*, 1904; U. S. Geol. Surv. Mon. *50*:45, *pl. 4, f. 9, 10*, 1907.

Description.—"Th. ramis articulatis, ramulis strictis compressis, ristichis, articulatis, foliis brevissimis, ato-squamæformibus, truncatis vel obtusis, quadrifarian imbricatis, arcte adpressis, dorso carinatis." Ettings., 1852.

. This genus was founded by Schenck in 1869 with *Thuites Hoheneggeri* Ettings. as the type. The latter received very elaborate treatment at the hands of the former author, and this was rounded out by Zeiller's description of the epidermal and stomatal characters in 1882[1]. It has been recorded from a large number of localities, although the bulk of the remains are rather unsatisfactory, and it is very doubtful if the Raritan or Magothy material as described by Newberry, Hollick, and the writer is correctly identified; at least it is not above suspicion. Characteristic remains of this species do occur, however, in the Kome beds of Greenland and the Trinity of Texas, in addition to the Barremian occurrences in Europe, while *Frenelopsis parceramosa* Font. from the older Potomac of Maryland and Virginia is extremely close to this species, and somewhat similar, but poorly preserved, remains are described from the English Wealden by Seward as *Becklesia anomala.*

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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[1] Zeiller, Ann. Sci., Nat., 6e sèr., Bot., t. xiii, p. 231.

Genus RARITANIA Hollick and Jeffrey.

(Mem. N. Y. Bot. Garden, vol. III, 1909, p. 26.)

RARITANIA GRACILIS (Newb.) Hollick and Jeffrey.

Frenelopsis gracilis Newb., Fl. Amboy Clays, 59, *pl. 12, f. 1–3a,* 1896.

Berry, Bull. Torrey Club, vol. 33: 167, 1906.

Raritania gracilis Hollick and Jeffrey, Mem. N. Y. Bot. Garden, vol. III: 26, *pl. 6, f. 4–7; pl. 9, f. 1–4; pl. 10, f. 14–17; pl. 19, f. 3–6; pl. 20, f. 1,* 1909.

Description.—Twigs of a conifer, represented in clays by crowded cylindrical branches of graceful aspect and slender forking habit. The leaves are reduced almost to the vanishing point, in fact most specimens fail to show any traces of leaves whatever, and it is possible that these spirally-arranged scale-like leaves of Newberry's description may have been founded upon deceptive material.

These twigs are unjointed, an objection against their former reference to the genus *Frenelopsis.* It has been suggested that they represent decorticated specimens of *Widdringtonites Reichii* (Ettings.) Heer, which is so common in the Raritan and overlying Magothy formation. The present species is recorded from both Delaware and Maryland.

Hollick and Jeffrey have shown (loc. cit.), since the foregoing was written, that the present species is not related to Frenelopsis, but constitutes a distinct genus.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Sub-Family ABIETEÆ.

Genus PINUS Linné.

(Sp. Pl., 1753, p. 1000.)

PINUS RARITANENSIS Berry.

Pinus sp., Newb., Fl. Amboy Clays, 47, *pl. 9, f. 5, 6; f. 7, 8 (?), f. 17, 18* (?), 1896.

Pinus raritanensis Berry, Bull. Torrey Club, vol. 36: 247, 1909.

Description.—It seems very desirable that at least the leaves which are included under Newberry's *Pinus sp.* should have a specific names since pine leaves of this type in fascicles of three occur to the southward in the Coastal Plain, and a definite name is therefore a necessity for purposes of intelligent citation. Whether the poorly-preserved cones and winged seeds, which occur in the same beds, are referable to the same species it is impossible to determine, and since in the overlying Magothy formation there are two types of leaves of *Pinus*, as well as quite different seeds, I have placed a query after Newberry's figures of cones and seeds in the above citation. *Pinus* seems to be confined to the upper part of the Raritan, although leaves, cones and seeds are common in much older deposits elsewhere, going back as far as the Jurassic. Leaves are recorded from the Kome, Kootanie, Trinity and Lakota formation, the Patapsco formation of Maryland and the Albian of Europe is remarkable for the large number of Pinus-like cones which it contains, and Heer has recorded five species from the Atane beds.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Sub-Family Taxodieæ.

Genus SEQUOIA Endl.

(Synop. Conif., 1847, p. 197.)

Sequoia Reichenbachi (Gein) Heer.[1]

Araucarites Reichenbachi Gein., Charakteristik, hft. 3:98, *pl. 24, f. 4,* 1842.

Cryptomeria primaeva Corda in Reuss, Verst. Böhm. Kreidef. ab. 2:89, *pl. 48, f. 1–11,* 1846.

Sequoia Reichenbachi Heer, Fl. Foss. Arct., vol. 1:83, *pl. 43, f. 1d, 2b, 5a,* 1868; Ibid., vol. 3, ab. 2:77, 101, 126, *pl. 12, f. 7c, d; pl. 20, f. 1–8; pl. 28, f. 2; pl. 34, f. 1; pl. 36, f. 1–8; pl. 37, f. 1, 2,* 1874; Ibid., vol. 6, ab. 2:52, *pl. 28, f. 7,* 1882.

[1] Only representative citations, chiefly American, of this widespread and persistent species are given.

Fontaine, Potomac Fl., 243, *pl. 118, f. 1, 4; pl. 119, f. 1–5,* etc., 1889.

Lesq., Cret. Fl., 51, *pl. 1, f, 10–10b,* 1874; Fl. Dakota Group, 35, *pl. 2, f. 4,* 1892.

Hollick, Trans. N. Y. Acad. Sci., Vol. 12:30, *pl. 1, f. 18,* 1892; U. S. Geol. Surv. Mon. 50:42, *pl. 2, f. 40; pl. 3, f. 4, 5,* 1907.

Nath, in Felix & Lenk, Beitr. Geol. u. Pal. Mexico, 2 Th. 1 hft., 1893.

Newberry, Fl. Amboy Clays, 49, *pl. 9, f. 19,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 59, *pl. 48, f. 15–18, 20,* 1903; Bull. Torrey Club, vol. 31: 69, *pl. 4, f. 8,* 1904; Ibid., vol. 32: 44, *pl. 1, f. 3,* 1905; Ibid. 33: 165, 1906.

Knowlton, Smith. Misc. Coll. vol. 4, pt. 1: 126, *pl. 12, f. 7, 8,* 1907; U. S. Geol. Surv. Mon. 32: 657, 1899; Bull. U. S. Geol. Surv. No. 257:131, *pl. 14, f. 3–5,* 1905.

Sequoia Couttsiae Hollick, Trans. N. Y. Acad. Sci., vol. 12: 30, *pl. 1, f. 5* (non Heer).

Description.—"S. ramis elongatis, foliis decurrentibus, patentibus, falcato-incurvis, rigidis, acuminatis." Heer, 1868.

This widespread Mesozoic species is not abundant in the Raritan formation, being only recorded from the single locality of Woodbridge, where it is not common. This relative rarity is probably to be explained by local climatic conditions due to altitude or to the character of the soil and its water content and their effect upon relative humidity. Of course, such an explanation is largely speculative. We do know, however, that Sequoia twigs are about the last fragments in floating vegetable debris to disintegrate, and that their remains are found in deposits in which the associated vegetation is reduced to an unrecognizable mass, so that it is safe to predicate that *Sequoia Reichenbachi* did not grow near the place where the Raritan sediments were being laid down and that such specimens as are preserved were floated into the Raritan basin by streams, perhaps from the uplands where they grew. In the succeeding

Magothy formation, this species and other conifers were excessively abundant in this general region, and this species occurs in great abundance in beds of approximately this latter age in every State from New York to Alabama.

Sequoia Reichenbachi has a recorded range on this continent from the Neocomian of Mexico to the Livingston formation of Montana, and it seems to have been equally at home during the greater part of the Cretaceous in Europe and the Arctic region. It is possible that these remains may represent more than a single species, but of this it is impossible to judge. The Tertiary *Sequoia Langsdorfii* has an almost equally wide range, both vertical and horizontal.

In the original description, Geinitz refers this species to the genus *Araucarites*, and several students since his day have pointed out its resemblance to the Eutacta section of the genus *Araucaria*. If this be the true affinity, then this Cretaceous *Araucaria* bore *Sequoia* cones, for the latter have been found attached to the twigs in a number of instances.

Occurence—Woodbridge.

Collections—N. Y. Botanical Garden.

SEQUOIA HETEROPHYLLA Velen.

Plate VI.

Sequoia heterophylla Velen., Gymnos. böhm. Kreidef., 22, *pl. 12, f. 12; pl. 13, f. 2–4, 6–9*, 1885; Sitz. K. böhm. Gesel. Wiss., Prag, 1888; 593. *f. 7, 8*.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 3, *pl. 1, f. 18*, 1892; U. S. Geol. Survey, Mon. 50: 41, *pl. 3, f, 2, 3*, 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Ward, 15th Ann. Rept. U. S. Geol. Survey, 378, 380, 382, 392, 1895.

Newb., Fl. Amboy Clays, 49, *pl. 6, f. 1–13*, 1896.

Knowlton, Bull. U. S. Geol. Survey, No. 257: 132, *pl. 16, f. 5*, 1905.

Berry, Bull. Torrey Club, vol. 33:165, 1906; Ibid., vol. 34: 189, 1907; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906.

Description.—"Zweige ruthenförmig unter spitzen Winkeln getheilt, ziemlich dünn und schlank. Blätter zweierlei: die schuppenförmigen sehr verlängert, mit stumpfen, nicht abstehenden Spitzen, locker dem Zweige aufsitzend; die der jüngeren Sprosse blattartig, zweireihig am Zweige geordnet, lineal, breit, dick, lederartig, vorne stumpf abgerundet, am Grunde merklich verschmälert, von mehreren Längsstreifen durchzogen. Der Zapfen unbekannt." Velenovsky 1885.

This characteristic species described originally from the Cenomanian and Senonian of Bohemia may be readily recognized by the form of the foliage—the flat lanceolate decurrent leaves above and the short and appressed leaves below. As yet no cones have been correlated with the leafy twigs in the American material. Newberry says of this species that it is one of the most common conifers of the Amboy clays, but mentions no localities. The writer has only found it in the upper Raritan at South Amboy, where it is very common, and at the Hylton Pits, and it has been collected by Hollick from a probably equivalent horizon at Kreischerville, Staten Island.

In the overlying Magothy formation it is a common species, with a recorded range from Marthas Vineyard to Maryland and in the allied Bladen formation of North Carolina. In the west it occurs in the Judith River beds of Montana. It is a distinctly younger element in the Raritan, allying that flora with the higher Upper Cretaceous beds.

Occurrences.—South Amboy, Hylton Pits.

Collections.—N. Y. Botanical Garden, U. S. National Museum.

SEQUOIA CONCINNA Heer.

Sequoia concinna Heer, Fl. Foss. Arct., vol. 7: 13, *pl. 49, f. 8b, c; pl. 50, f. 1b; pl. 51, f. 2–10; pl. 52, f. 1–3; pl. 53, f. 1b,* 1883.

Hollick, U. S. Geol. Surv., Mon. 50: 43, *pl. 2, f. 41,* 1907.

Cones of Sequoia sp., Hollick in Newb., Fl. Amboy Clays, note, p. 49, *pl. 9, f. 4, 4a,* 1896.

Description.—"S. ramis alternis, ramulis congestis, junioribus elongatis, foliis basi valde decurrentibus, lineari-subulatis, apice acuminatis, rectis vel leviter curvatis, dorso carinatus; strobilo breviter ovali, 23 mm. longo, 20 mm. lato, squamis 5–6 angularibus, medio unbonatis, margine striatis." Heer, 1883.

This is doubtfully a member of the Raritan flora and probably came from Newberry's locality "near Keyport," *i. e.,* Cliffwood bluff, which is in the overlying Magothy formation, as I have found cones of this species at that place. Since, however, there is no reason why this species should not occur in the Raritan, and the present uncertainty as to the locality from which Newberry's specimens were collected cannot be cleared up, it is retained as a member of the Raritan flora.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden, Johns Hopkins University..

Genus GEINITZIA Endl.

(Synop. Conif., 1847, p. 280.)

GEINITZIA FORMOSA Heer.

Geinitzia formosa Heer, Neue Denks. Schweiz Gesell., vol. 24: 6, *pl. 1, f. 9; pl. 2,* 1871.

Newb., Fl. Amboy Clays, 51, *pl. 9, f. 9,* 1896.

Hollick, Trans. N. Y. Acad. Sci., vol. 16: 129, *pl. 12, f. 1, 2,* 1897.

Knowlton, Bull. U. S. Geol. Survey, No. 163: 28, *pl. 5, f. 1, 2,* 1900.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 57, 1903; Bull Torrey Club, vol. 31: 68, *pl. 4, f. 2, 3,* 1904.

Geinitzia sp., Newb., Proc. N. Y. Lyc. Nat. Hist., 2nd ser.: 10, 1873.

Description—"ramulis elongatis, virgatis, foliis omnino tectis, foliis, subfalcatis, angustis, apice valde attenuatis, uninerviis, ramis adultis pulvinis rhombeis obtectis." Heer, 1871.

This species, like *Sequoia Reichenbachi*, occurs sparingly at the Woodbridge horizon, and like the latter is more abundant in the overlying Magothy formation at Cliffwood bluff. It resembles this species considerably, but may be distinguished by the thicker twigs with decurrent pointed leaves, which are more curved and less rigid than in the *Sequoia* and with smaller intermediate scale-like leaves, which are altogether wanting in the latter. *Geinitzia formosa* was described originally from the Senonian of Saxony, and it also ranges upwards into the Montana formation of Wyoming. It is another species which serves to ally the Raritan with younger deposits elsewhere.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family TAXACEÆ.

Sub-Family TAXEÆ.

Genus PROTOPHYLLOCLADUS Berry.

(Bull. Torrey Club, vol. XXX, 1903, p. 440.)

PROTOPHYLLOCLADUS SUBINTEGRIFOLIUS (Lesq.) Berry.

Plate IX.

Phyllocladus subintegrifolius Lesq., Amer. Jour. Sci., vol. 46: 92, 1868; Cret. Fl. 54, *pl. 1, f. 12,* 1874; Fl. Dakota Group, *34, pl. 2, f. 1–3,* 1892.

Thinnfeldia Lesquereuxiana Heer, Fl. Foss. Arct., vol. 6, ab. 2: *37, pl. 44, f. 9, 10; pl. 46, f. 11, 12a, b,* 1882.

Hollick, Trans. N. Y. Acad. Sci., vol. 11: 99, *pl. 3, f. 6,* 1892.

Newb., Fl. Amboy Clays, 59, *pl. 11, f. 1–17,* 1896.

Thinnfeldia subintegrifolia Knowlton, Bull. U. S. Geol. Surv., No. 152: 228, 1898.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, 419, *pl. 3, f. 4, 5, pl. 36, f. 6,* 1898; Bull. N. Y. Bot. Garden, vol. 2; 403, *pl. 41, f. 13, 14,* 1892.

Protophyllocladus subintegrifolius Berry, Bull. Torrey Club, vol. 30: 440, 1903; Ibid., vol. 31: 69, *pl. 1, f. 5,* 1904; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906; Johns Hopkins Univ. Circ. new ser., 1907, No. 7: 89–91, *f. 6.*

Hollick, U. S. Geol. Surv. Mon. 50: 36, *pl. 5, f. 1–6,* 1907.

Description.—Leaves oblong to linear in outline and coriaceous in texture, from 3 cm. to 17 cm. in length by 0.6 cm. to 3 cm. in width. Apex usually obtuse, rarely pointed. Base decidedly and narrowly cuneate to the short petiole. Margins entire below, above obtusely dentate or undulate, with occasionally teeth which are acute. Midrib stout below becoming attenuated above and frequently disappearing some distance below the apex. Laterals numerous, close, immersed; they branch at an angle of about 20°, running nearly straight and approximately parallel to the margin, sometimes forking. Stomata scattered on both surfaces, with typical guard cells.

This is a widespread species ranging in considerable abundance from Greenland to New Jersey and west to Kansas and Nebraska. Originally referred to *Phyllocladus* by Lesquereux, his type is almost identical with certain phylloclads of modern members of this genus. Subsequently discovered remains from Kansas are considerably larger than the type, as are also a number of the Greenland specimens. Some of the Raritan forms have a somewhat different aspect, being long and narrow; sometimes the margins are entire, often they are more or less sharply toothed.

Much controversy has centered around these forms and especially around the older Mesozoic forms referred to the genus *Thinnfeldia* Ettings., to which these later forms were once referred. The latter genus has been referred successively to the conifers, ferns and cycads. There has never been much doubt that the later forms were gymnospermous. The writer can positively affirm this conclusion, and also that they are true phylloclads and not leaves in the strict morpholigical sense.

Whether or not they are closely related to the modern genus *Phyllocladus* is still in doubt, although there are some excellent arguments for such a relationship. While fossil remains of undoubted relationship to this genus are extremely rare, Gothan describes wood of similar type from the Jurassic of the east coast of Greenland, under the name of *Phyllocladoxylon*.[1]

Occurrence.—Newberry states that he had some hundreds of specimens from the Amboy Clays, but gives no localities. The writer has collected it from Florida Grove and vicinity.

Collections.—Johns Hopkins University, N. Y. Botanical Garden.

Order GINKGOALES.

Genus BAIERA Braun.

(Flora, 1841, p. 33.)

BAIERA INCURVATA Heer.

Baiera incurvata Heer, Fl. Foss. Arct. vol. 6, ab. 2:45. *pl. 13, f. 6,* 1882.
Newb., Fl. Amboy Clays, 60, *pl. 10, f. 6,* 1896.

Description.—"B. foliis dichotome laciniatis, segmentis angustis, 2-3 mm. latis, linearibus, apice obtusis, incurvatis, nervis longitudinalibus, 3-4, obsoletis." Heer, 1882.

A single incomplete specimen from Woodbridge is identified by Prof. Newberry with this poorly characterized species of Heer, which is based on very incomplete remains. It seems almost certain that the apical curvature which the latter makes as one of the characteristics of this species is simply accidental. The generic relationship seems to be correct and it is probable that *Baiera leptopoda,* Heer, from the same horizon in Greenland belong to the same species.

The genus is an old one, appearing late in the Paleozoic and becoming widespread and very important in the Triassic and

[1] Kungl. Svenska Vetensk. Akad. Handl., Bd. 42, No. 10, 1907.

Jurassic. It continued into the Cretaceous, but is much reduced in numbers and importance, a single form occuring in the Lower Cretaceous.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CZEKANOWSKIA Heer.

(Fl. Foss. Arct., vol. IV, ab. ii, 1876, p. 70.)

CZEKANOWSKIA CAPILLARIS Newb.

Czekanowskia capillaris Newb., Fl. Amboy Clays, 61, *pl. 9, f. 14–16,* 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (Nomen nudum.)

Description.—Leaves linear or capillary, long and slender, undivided (?) or dichtomously forked. Length 8 cm. to 10 cm. Judging by the extremely poor material at our command they grew in bundles and were apparently caducous.

The genus was established by Heer in 1876, and its relations have caused considerable discussion, some authors comparing it with *Isoetes.* Both Schenk and Seward, from the stomatal character, place the genus among the Gymnosperms. Among the latter it falls most naturally in the order Ginkgoales, although this relationship is disputed in some quarters. It is essentially a Jurassic type, appearing, however, in the Rhaetic and surviving as late as the Upper Cretaceous, apparently becoming extinct in the Cenomanian, the European *Czekanowskia nervosa* Heer, which is recorded by Fontaine[1] from the Lower Cretaceous of the Black Hills, ranging from the Aptian through the Albian into the Cenomanian of Portugal.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

[1] Fontaine, Ann, Rept. U. S. Geol. Surv. 19th, pt. 2, 1899, p. 685, *pl. 169, f. 1, 2.*

Class ANGIOSPERMAE.

Sub-Class MONOCOTYLEDONAE.

Order LILIALES.

Family SMILACACEÆ.

Genus SMILAX Linné.

(Sp. Pl., 1753, p. 1028.)

SMILAX RARITANENSIS Berry.

Plate XXIII, Fig. 3.

Paliurus ovalis Dawson, Newb., Fl. Amboy Clays, 107, *pl. 23, f. 8, 9,* 1896 (non Daws.)
Smilax raritanensis Berry, Bull. Torrey Club, vol. 36: 248, 1909.

Description.—Leaves of small size, ovate elliptical in outline, with entire margins, obtusely pointed apex and slightly cuneate base, 3.5 cm. to 4 cm. in length by 1.5 cm. to 2 cm. in breadth. Primaries 3, of medium size, diverging at acute angles from the extreme base, the laterals regularly curving upward and joining the midvein at the summit. Secondaries not visible except 1 or 2 transverse internal ones, and a few curved camptodrome external ones.

This species was identified by Prof. Newberry with *Paliurus ovalis* Dawson[1] which it somewhat resembles and this latter species has been reported by Lesquereux[2] from the Dakota Group and by Hollick[3] from Marthas Vineyard. These occurences may represent Dawson's species, but the Raritan leaves are obviously different, being relatively shorter and broader and of an altogether different aspect.

[1] Dawson, Trans. Roy. Soc. Can., vol. 3, sec. 4: 14, pl. 4, f. 4, 8, 1886.
[2] Lesquereux, Fl. Dakota Group, 166, pl. 35, f. 7, 1892.
[3] Hollick, Mon. U. S. Geol. Surv., vol. 50: 91, pl. 34, f. 14, 1907.

Prof. Newberry remarks of the difficulty of correlating these and other fossil species with the modern species of *Paliurus* which usually has serrate or crenate leaves, and while no new material has been obtained, it seems desirable to place these leaves in the genus *Smilax* which contains many very similar modern leaves. Lesquereux describes two handsome species of *Smilax* from the Dakota Group, both of which are much larger leaves and differ in other respects from the Raritan species.

Occurence.—Locality unknown.

Collections.—New York Botanical Garden.

Sub-Class DICOTYLEDONAE.

Order MYRICALES.

Family MYRICACEÆ.

Genus MYRICA Linné.

(Sp. Pl., 1753. p. 1024.)

MYRICA HOLLICKI Ward.

Plate X, Fig. 6.

Myrica Hollicki Ward, Amer. Jour. Sci., vol. 45: 437, 1893.
Hollick, Mon. U. S. Geol. Surv. vol. 50: 53, *pl. 7, f. 24*, 1907.
Berry, Bull. Torrey Club, vol. 36: 249, *pl. 18, f. 2*, 1909.
Myrica grandifolia Hollick, Trans. N. Y. Acad. Sci., vol. 12: 5, *pl. 3, f. 1*, 1892. (non Schimper, 1872).

Description.—Leaves of large size, 18 cm. to 22 cm. in length by 4 cm. to 6 cm. in width, broadly lanceolate in outline, widest near the middle and tapering equally to the acuminate apex and the cuneate base. Margins entire for a short distance above the base, elsewhere sharply serrate. Petiole long and stout. Midrib also stout. Secondaries slender, very numerous, being not more than 2 mm. to 3 mm. apart, branching from the midrib at

angles of 45° or slightly more, subdividing and inosculating near the margin and sending branches into the marginal teeth.

The type of this exceedingly handsome species is a single incomplete specimen, collected at Tottenville, Staten Island, sixteen or more years ago, and now preserved in the Museum of the Staten Island Association of Arts and Sciences. A single specimen was collected from the lower Raritan at Milltown. It is a larger, slightly broader leaf with slightly less prominent teeth, but is obviously identical with the type.

Occurence.—Milltown.

Collections.—U. S. National Museum.

Myrica emarginata Heer.

Plate X, Fig. 5.

Myrica emarginata Heer, Fl. Foss. Arct. vol. 6, ab. 2: 66, *pl. 41, f. 2,* 1882.
Lesq., Fl. Dakota Group, 67, *pl. 12, f. 1,* 1892.
Newb., Fl. Amboy Clays, 62, *pl. 41, f. 10, 11,* 1896.

Description—"M. foliis oblongis, integerrimis, apice emarginatis, basi attenuatis, nervis secundariis subtilissimis." Heer 1882.

The Raritan leaves referred to this species by Prof. Newberry are not quite typical of this species, being somewhat more elongate and lacking the strictly obovate outline shown in the Atane leaves and those from the Dakota group. Recent collections of this species from the southern Coastal Plain also depart from the Raritan leaves in the direction of the type.

The Raritan leaves are 5.5 cm. to 7 cm. in length and 1.8 cm. to 2.5 cm. in breadth, oblong lanceolate in outline and entire, with a strongly emarginate apex and cuneate, narrowly descending base. Secondaries thin, 8 to 10 pairs, branching from the midrib at an angle of about 45°, curving upward, camptodrome.

Occurrence—Locality unknown.

Collections—N. Y. Botanical Garden.

MYRICA NEWBERRYANA Hollick.

Plate X, Fig. 2.

Myrica Newberryana Hollick in Newb., Fl. Amboy Clays, 63, *pl. 42, f. 5,* 1896.

Description.—Leaves small, lanceolate in outline, about 2.5 cm. long by 0.8 cm. in greatest width. Apex obtusely pointed. Base apparently acute. Margin entire for one-third of the distance above the base, the remainder with somewhat irregular, rounded, dentate teeth. Venation fine but distinct. Secondaries numerous, 7 or 8 pairs, sub-opposite, camptodrome.

This species is based on a few fragmentary specimens from the upper Raritan, of which the leaf figured is the most complete. It is apparently quite distinct from the other members of the Raritan flora.

Occurrence.—South Amboy, Milltown.

Collections.—N. Y. Botanical Garden.

MYRICA FENESTRATA Newb.

Flate X, Fig. 3.

Myrica fenestrata Newb., Fl. Amboy Clays, 63, *pl. 42, f. 32,* 1896.

Description.—Leaf lanceolate in outline, equally pointed at both ends, 5 cm. to 6 cm. in length by 1.4 cm. in greatest width. Margin slightly undulate. Midrib strong. Secondaries stout, numerous, regularly alternate, branching from the midrib at a wide angle, nearly 90°, and running straight almost to the margin where their ends are joined by flat arches, somewhat suggestive of a *Ficus* or a *Eucalyptus.*

This species was based on a single incomplete specimen, and only two additional fragments have been found in the later collections. While its inclusion in the genus *Myrica* is not above question, it seems closer to this type than to any other which has sug-

gested itself, and as a distinct type of Raritan plant it deserves a place in any enumeration of the Raritan flora.

Occurrence.—Sayreville, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Myrica cinnamomifolia Newb.

Plate X, Fig. 7.

Myrica cinnamomifolia Newb., Fl. Amboy Clays, 64. *pl. 22, f. 9–14*, 1896.

Description.—Leaves of medium size, elliptical in outline, pinnately lobate or panduriform. Lobes obtusely rounded, separated by shallow rounded sinuses of variable width or the margin may be strongly undulate with two or three broad scallops, or one margin may be lobate and the other scalloped. Apex obtusely pointed. Base pointed, slightly decurrent. Petiole stout, 2.5 cm. in length. Leaves very variable in size and outline, ranging from 4.5 cm. to 7.5 cm. in length by 2 cm. to 4 cm. in breadth. Basal half or one-third of the leaf entire, this feature with the ascending opposite basal secondaries giving fragmentary specimens the appearance of a *Cinnamomum* or a *Sassafras*. Midrib mediumly stout. Secondaries few, not more than 2 or 3 pairs, branching from the midrib at an acute angle, curved, indifferently camptodrome and craspedodrome; the basal pair are subopposite branching from the midrib a short distance above the base and curving upward; they traverse ⅓ or ½ the distance to the apex ending in the tip of the lowest lobe or camptodrome, this variability in their course is well shown in the specimen figured; the other secondaries may be alternate or sub-opposite, and they may end in a lobe or not; the second one is a considerable distance above the basal pair, as much as 2.5 cm. in one specimen, and it subtends a somewhat wider angle with the midrib.

These curious leaves are not uncommon, but are mostly incomplete. Professor Newberry has figured several, which clearly show their variable nature. The latter author was not at all

certain of their relation with *Myrica* and was inclined to associate them with the triple-veined leaves of some Lauraceous genus such as *Cinnamomum,* although the latter are entire as a rule. *Cinnamomum membranaceum* (Lesq.) Hollick has a lateral sinus on each side, but is obviously a triple-veined leaf, while the present species, despite its appearance, is pinnately veined, as is well shown in a number of the specimens.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Myrica acuta Hollick.

Plate X, Fig. 1.

Myrica acuta Hollick in Newb., Fl. Amboy Clays, 65, *pl. 42, f. 35,* 1896.

Description.—Leaves small, lanceolate in outline, about 3 cm. in length by 1 cm. in width. Apex and base about equally and acutely pointed. Margin entire in the basal half of the leaf, above with somewhat remote and irregularly placed, sharp, denticulate teeth. Secondaries about six pairs, alternate, branching from the midrib at a wide angle and running nearly straight to within a short distance of the margin, where they bend sharply upward and arch to join the secondary next above. These arches are approximately parallel with the margin and give the appearance of a continuous marginal vein. Branches from these arches enter the marginal teeth.

This species, while based upon fragmentary material, is well marked and quite distinct from any other member of the Raritan flora. Prof. Newberry failed to leave any memorandum of the locality from which it was collected, and no subsequent specimens have been discovered.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

MYRICA RARITANENSIS Hollick.

Plate X, Fig. 4.

Myrica raritanensis Hollick in Newb., Fl. Amboy Clays, 65, *p*
42, f. 34, 1896.

?Phyllites obscura Hollick in Newb., Ibid., 131, *pl. 42, f. 3*
1896.

Description.—Leaves small, ovate in outline, about 3 cm. lo by 1.3 cm. wide, broadest near the middle and tapering equal in both directions. Apex presumably acute. Base cuneate, acut Margin entire in the lower half of the leaf, coarsely denta above. Venation obscure, only a few pairs of thin secondari being visible.

The form described by Hollick as *Phyllites obscura* is probat an abnormal leaf of this species, and is here included under with a query. Species based on single specimens from unknov localities and with affinities undeterminable are of little val unless they serve as horizon markers, which this *Phyllites* do not, so that it is desirable from every point of view to make t foregoing disposition of it.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus COMPTONIA Banks.

(Gaertn. Fr. & Sem., vol. II. 1791, p. 58. pl. xc.)

COMPTONIA MICROPHYLLA (Heer) Berry.

Rhus microphylla Heer. Fl. Foss. Arct., vol. 3, ab. 2: 117, *pl. 3*
f. 18, 1874.

Myrica (Comptonia) parvifolia Heer. Ibid., vol. 7: 77. *pl. 71.*
12, 1883.

Myrica (Comptonia) parvula Heer. Ibid., 20. *pl. 55. f. 1–3.*
Newb., Fl. Amboy Clays, 63. *pl. 19. f. 6,* 1896.

Comptonia microphylla Berry. Amer. Nat., vol. 40: 508. *pl. 4,*
f. 3. 4, 1906.

Description.—Leaves variable in size, 1.1. cm. to 5 cm. in length by 0.4 cm. to 2 cm. in breadth, ovate lanceolate in outline with an obtusely pointed apex and a cuneate, slightly decurrent base. Margin divided into from 2 to 4 slightly aquiline, rounded, obtusely pointed lobes, the intervening rounded sinuses cut about half way to the midrib. Secondaries craspedodrome, one to each lobe. In the larger leaf there is a second secondary some distance below the one which traverses one of the lobes, and, while this is not visible throughout its length, it was probably camptodrome as in the leaves of the modern *Comptonia*.

It is difficult to understand on what ground Prof. Heer founded his two species *parvula* and *parvifolia* unless it was because they were supposed to have come from different geological horizons. He compares both to the European *Comptonia œningensis* Al. Br., although their resemblance to that species, as a matter of fact, is not very close. The two are exactly similar, as is the *Rhus* included in the foregoing synonymy, except as to size. The Raritan specimen which Newberry identified as *parvula* is closer to *parvifolia,* which fact is noted by the latter author, who presumably hesitated to refer a Cretaceous leaf to a species of the Miocene, as these Arctic deposits were thought to be at that time. The writer has elsewhere (loc. cit.) called attention to the probability of Heer's specimens having come from practically the same horizons, so that there are no valid reasons for maintaining their fancied distinctness.

The earliest leaves of the modern *Comptonia peregrina* (Linné) Coulter usually are very similar to this fossil species. These latter might be considered as the abbreviated leaves, so common in seedling plants and hence without phylogenetic meaning, or they may be considered as representing the normal leaves of these ancient Comptonia plants. The first assumption seems doubtful, not only because of the perishable nature of seedling leaves in general, but because it is unusual for them to become detached and fossilized, and it would be a rather singular coincidence for this to have occurred in New Jersey, Greenland, and Europe only once and at the same geological horizon. Furthermore, no other species of *Comptonia* are known from either the Raritan clays, or the Atane and Patoot schists, from which they

could have been derived. It would seem that the conclusion reasonable that these are the normal leaves of the earliest know Comptonias, and that the modern seedling leaves are truly at vistic.

The remains of this species are scanty, the Raritan occurren being based on a single specimen, and all are very similar to th contemporaneous *Comptonia antiqua* Nilsson, described abo seventy-five years ago from Sweden.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Order JUGLANDALES.

Family JUGLANDACEÆ.

Genus JUGLANS Linné.

(Sp. Pl., 1753, p. 997.)

JUGLANS ARCTICA Heer.

Juglans arctica Heer, Fl. Foss. Arct., vol. 6, Ab. 2: 71, *pl. 40, 2; pl. 41, f. 4c; pl. 42, f. 1–3; pl. 43, f. 3,* 1882.
Lesq., Fl. Dak. Group, 68, *pl. 19, f. 3; pl. 39, f. 5,* 1892.
Newb., Fl. Amboy Clays, 62, *pl. 20, f. 2,* 1896.
Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, *pl. 3, f. 7,* 189
Berry, Ann. Rep. State Geol. (N. J.) for 1905; 139, *pl. 2 f. 1,* 1906; Bull. Torrey Club, vol. 33: 170, 1906.
Hollick, U. S. Geol. Survey. Mon. 50: 54, *pl. 9, f. 6–* 1907.

Ficus atavina Hollick, Trans. N. Y. Acad. Sci., vol. 11: 103; *p 4, f. 5,* 1902.

Description.—"I nuce ovali, 34 mm. longa, 17 mm. lata; foli magnis, foliolis ovalibus, basi inæquilateralibus, integerrimi nervo medio valido, nervis secundariis angulo semirecto egr dientibus, curvatis." Heer, 1882.

The leaves of this species vary considerably in size and outlin which might be expected in the present genus. Heer's type m

terial is somewhat imperfect and in some cases it is difficult to distinguish it from some of the forms referred to the same author's *Juglans crassipes*, although the latter is on the whole a much larger form with a narrower base and less oblong in outline.

Juglans arctica is oblong-ovate in outline with an obtusely pointed apex and a rounded, generally inequilateral base. The petiole and midrib are stout. Secondaries numerous, well marked, parallel, camptodrome. Size varying in complete specimens from 9 cm. to 15 cm. in length and from 3 cm. to 6 cm. in width. The single, nearly-perfect leaf found in the Raritan at Woodbridge, which Newberry provisionally refers to this species, is about 15 cm. in length by 5 cm. in breadth, oblong-ovate in outline, with a rounded, somewhat inequilateral base, a stout petiole and midrib, about 13 pairs of subopposite to alternate camptodrome secondaries which branch from the midrib at a wide angle. There seems to be little doubt of the correctness of Prof. Newberry's determination.

A nut and catkins are associated with the leaves at the type locality in the Atane beds of Greenland which confirm their reference to this genus. The species has a wide range, having been recorded from Marthas Vineyard, Block Island, Staten Island, New Jersey, North Carolina, South Carolina and Kansas.

Occurrence—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order SALICALES.

Family SALICACEÆ.

Genus POPULUS Linné.

(Sp. Pl., 1753, p. 1034.)

POPULUS APICULATA Hollick.

Plate XI, Fig. 4.

Populus apiculata Hollick, Trans. N. Y. Acad. Sci., vol. 12:4, *pl. 3, f. 2,* 1892; U. S. Geol. Surv. Mon. 50:49, *pl. 7, f. 28, 29,* 1907 (?)

Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 65, *pl. 15, f. 3, 4,* 1896.
Berry, Bull. Torrey Club, vol. 33: 172, 1906.

Description.—Leaves ovate to orbicular in general outline, 8 cm. to 10 cm. in length by 5 cm. to 7 cm. in width. Apex somewhat abruptly produced into an acuminate tip. Base cuneate to rounded or almost truncate. Margins entire. Petiole comparatively long and stout. Midrib mediumly stout. Secondaries 5 or 6 pairs, subopposite below, alternate above, slender, branching from the midrib at angles of from 45° to 50° and arching upward, camptodrome.

Prof. Newberry compared this species with *Populus hyperborea* Heer and *Populus Berggreni* Heer, but seemed doubtful of its real relation to *Populus.* It is also recorded from Staten and Long Islands, from the Magothy formation of Delaware and from the Tuscaloosa formation of Alabama. In the latter region it is quite common and well illustrates the variability from the narrow to the almost orbicular forms.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Populus orbicularis (Newb.) Berry.

Plate XI, Figs. 5, 6.

Phyllites orbicularis Newb., Fl. Amboy Clays, 130, *pl. 24, f. 7, 8,* 1896.
Populus orbicularis Berry, Bull. Torrey Club, vol. 36: 250, 1909.

Description.—Leaves orbicular in outline, with a very slight emargination at the apex and with a slight decurrence from the rounded base to the apparently short petiole. Length about 5 cm. and breadth usually 2 or 3 millimeters less than 5 cm. Margin entire. Midrib mediumly stout. Secondaries camptodrome, relatively coarser than in the preceding species, about 6 pairs, subopposite; they branch from the midrib at a wide angle, are less curved than in the preceding and inclined to be somewhat flexuous.

Newberry calls attention to the resemblance of this species to *Populus hyperborea* Heer, but is quite positive that it is not related to *Populus*. The writer does not share this opinion. Unless we are prepared to discard *Populus* for *Phyllites* in a large number of cases, this species should surely be referred to the former genus. It is a remarkable coincidence referred to in the present connection only because of its general interest that the type of Sternberg's genus *Phyllites* was very likely a true *Populus* and that *Phyllites* as a form genus for undeterminable leaves will probably have to be dropped eventually in favor of some other name.

The present species is based upon scanty but perfect material confined to the Sayreville horizon.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Genus SALIX Linné.

(Sp. Pl., 1753, p. 1015.)

SALIX NEWBERRYANA Hollick.

Plate XI, Fig. 2.

Salix Newberryana Hollick in Newb., Fl. Amboy Clays, 68, *pl. 14, f. 2–7,* 1896.

Description.—Leaves lanceolate in outline, 8 cm. to 12 cm. in length, by 1 cm. to 2.5 in breadth, with an elongated acuminate apex and a cuneate or more or less rounded base, petiolate. Margins finely sharp-serrate to within a short distance of the base. Midrib mediumly stout. Secondaries fine, more or less obsolete on the upper surface of the leaf, but well defined on the under side. They are numerous, parallel, branching from the midrib at an angle somewhat over 40°, and sweeping upward in broad curves, camptodrome. Areolation polygonal, relatively coarse.

This species is frequent in the Raritan, but the specimens are mostly incomplete. To the localities enumerated by Prof. New-

berry, Milltown is added as a result of recent work, showing that this species is present from the bottom to the top of the Raritan formation. It has also been collected by the writer from the Bladen formation of North Carolina.

Occurrence.—Sayreville, Woodbridge, South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

SALIX LESQUEREUXII Berry.

Salix proteæfolia Lesq., (non Forbes, 1829). Amer. Jour. Sci., vol. 46:94, 1868; Rept. on Clays, N. J., 29, 1878; Cret. Fl., 60, *pl. 5, f. 1–4,* 1874; Cret. & Tert. Fl., 42, *pl. 1, f. 14–16; pl. 16, f. 3,* 1883; Fl. Dakota Group, 49, 1892.

Newb., Fl. Amboy Clays, 66, *pl. 18, f. 3, 4,* 1896.

Kurtz, Revista Mus. La Plata, 10: 51, 1902.

Berry, Bull. Torrey Club, vol. 33: 171, *pl. 7, f. 2,* 1906; Ann. Rept. State Geol. (N. J.) for 1905, 139, 1906.

Salix proteæfolia longifolia Lesq., Fl. Dakota Group, 50, *pl. 64, f. 9,* 1892.

Proteoides daphnogenoides Newb., Fl. Amboy Clays, 72 (pars.) *pl. 32, f. 11,* 1896 (non *f. 13, 14*).

Dewalquea groenlandica Newb., 129 (pars.), *pl. 41, f. 12* (non *f. 2, 3*).

Salix Lesquereuxii Berry, Bull. Torrey Club, vol. 36: 252, 1909.

Description.—Leaves ovate-lanceolate in outline, somewhat more acuminate above than below, variable in size, ranging from 6 cm. to 12 cm. in length, and from 1.1 cm. to 2. 2. cm. in greatest width, which is usually slightly below the middle. Petiole, stout, much longer than in *Salix flexuosa,* ranging up to 1.2 cm. in length. Midrib stout below, tapering above. Secondaries numerous, sometimes as many as 20 pairs; they branch from the midrib at angles of about 45° and are parallel and camptodrome.

Unfortunately, the name given this species was used for another by Forbes in 1829, so that it becomes necessary to rename it, and no name can be more appropriate than that of its distinguished describer, Leo Lesquereux, for whom it is here named.

This is an exceedingly variable species, as might be expected in a *Salix*, and Lesquereux established several varieties, of which at least one, *i. e. linearifolia*, is referable to *Salix flexuosa* Newb. Some of Lesquereux's forms are distinguishable with difficulty from the latter, and this is especially shown in the leaves which he figures on Plate 1 of his Cretaceous and Tertiary Flora. They are, however, larger and somewhat more robust, of a thicker texture and broadest near the base, from which they taper upward to an exceedingly acuminate tip. In general, *Salix Lesquereuxii* is a relatively much broader, more ovate form with more numerous and better seen secondaries and a longer petiole. It is a characteristic Cenomanian species in both the east and the west, and has even been reported from the Cretaceous of Argentina, by Kurtz (loc. cit.). It is abundant in the Raritan formation, both in the lower and upper beds.

Occurrence.—Sayreville, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

SALIX FLEXUOSA Newb.

Salix flexuosa Newb., Later Ext. Floras, 21, 1868; Ill. Cret & Tert. Plants, *pl. 1, f. 4,* 1878; U. S. Geol. Surv. Mon. 35: 56, *pl. 2, f. 4; pl. 13, f. 3, 4; pl. 14, f. 1,* 1898.

Berry, Ann. Rept. State Geol. (N. J.) for 1905: 145, 1906; Bull. Torrey Club, vol. 33: 171, 1906.

Salix proteæfolia linearifolia Lesq., Fl. Dakota Group, 49, *pl. 64, f. 1–3,* 1892.

? Hollick, U. S. Geol. Surv. Mon. 50: 52, *pl. 8, f. 12,* 1907.

Salix proteæfolis flexuosa (Newb.) Lesq. loc. cit., 50, *pl. 64, f. 4, 5,* 1892.

Hollick, Bull. Torrey Club, vol. 21: 50, *pl. 174, f. 5,* 1894; Ann. N. Y. Acad. Sci., vol. 11: 59, *pl. 4, f. 5a,* 1898; U. S. Geol. Surv. Mon. 50: 51, *pl. 8, f. 5, 6a; pl. 37, f. 8b,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 67, *pl. 48, f. 12; pl. 52, f. 2,* 1903.

Description.—Leaves narrow, linear-lanceolate in outline, equally pointed at the apex and base, short petioled, ranging from 5 cm. to 10 cm. in length and from 8 mm. to 13 mm. in width. Margins entire. Midrib stout below, tapering above, usually somewhat flexuous. Secondaries more or less remote, about 10 alternate pairs, branching from the midrib at angles varying from 35° to 45°, camptodrome, of fine calibre and often obsolete.

This species was described by Newberry in 1868 from the Dakota Group. Lesquereux in his Flora of the Dakota Group makes it one of the varieties of his *Salix proteæfolia,* but it is obviously entitled to independent specific rank. It has not heretofore been known from the Raritan formation, but is found to be sparingly represented in the Upper beds at South Amboy. It is pre-eminently a species which characterizes the Magothy and allied formations from Marthas Vineyard to Alabama, being especially abundant in New Jersey and Maryland.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

SALIX RARITANENSIS Berry.

Salix membranacea Newb. (non Thuill, 1799) Later Ext. Floras, 19, 1868; Fl. Amboy Clays, 66, *pl. 29, f. 12,* 1896; U. S. Geol. Surv., Mon. 35: 59, *pl. 2, f. 5–8a,* 1898.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 50, *pl. 8, f. 10;* 1907 (f. 23 ?).

Salix raritanensis Berry, Bull. Torrey Club, vol. 36: 250, 1909.

Description.—Leaves broadly lanceolate in outline, often unsymmetrical, large, petiolate. Length about 13 cm. and breadth at the widest part, which is toward the base, about 3 cm. Base rounded and obtuse. Apex narrowed and acute. Texture smooth and thin. Midrib slender, somewhat curved. Secondaries remote, branching from the midrib at an angle of 45° and curving upward in parallel courses, camptodrome.

This is another species of *Salix* which it is difficult to define with precision. If the emphasis is laid upon the large size, thin texture, and rounded base, we have characters which are easily recognized and which can be made constant by elimination. It is apparently common in the lower Raritan and has been reported by Hollock (loc. cit.) from Marthas Vineyard, the latter horizon probably of Magothy age. I have queried the small leaf figured by Hollick from Kreischerville, Staten Island, as it seems to be different, although it may be only a small leaf of this species. The latter author has tentatively included *Salix mattewanensis* Berry, which comes from the Magothy formation at Cliffwood, N. J., under this species. This is, in the writer's judgment, perfectly distinct and represents a much smaller, less elongated leaf, of a different consistency and venation.

Unfortunately the original name *Salix membranacea* is preoccupied, so that it becomes necessary to propose a new name, *raritanensis* being here suggested.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Salix inæqualis Newb.

Plate XI, Fig. 3.

Salix inæqualis Newb., Fl. Amboy Clays, 67, *pl. 16, f. 1, 4, 6; pl. 17, f. 2–7,* 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. XI: 419, *pl. 38, f. 4a,* 1898.

Description.—Leaves elongate-lanceolate in outline, 7 cm. to 12 cm. in length by 1 cm. to 2 cm. in breadth, generally broadest near the base and tapering upward to a long, narrow, acuminate tip. Base cuneate. A long curved petiole sometimes present. Midrib slender, flexuous. Secondaries slender, numerous, branching from the midrib at acute angles and curving upward, camptodrome, sometimes invisible.

These leaves are often unsymmetrical, and their reference to *Salix* is not conclusively established. They are common at the

Woodbridge locality and are very close to *Salix Lesquereuxii* Berry, which is also present in the Raritan formation and widespread in somewhat later deposits of Magothy and Dakota age or their equivalents. It is possible that these two forms should be united, in fact Hollick in a recent publication[1] tentatively places the Staten Island leaf referred to in the above citation under the latter species. However, the writer does not feel justified in making a change at the present time. Furthermore the Arrochar locality is probably Raritan in age, while the Block Island and Marthas Vineyard floras are probably of Magothy age.

The whole question of a classification of all the Raritan Salix-like leaves, which will be proper from a botanical standpoint, is beset with the greatest difficulties, so that in the absence of positive assurance the least possible amount of change is desirable.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

SALIS PSEUDO-HAYEI Berry.

Plate XI, Fig. 1.

Salix sp., Newb., Fl. Amboy Clays, 68, *pl. 42, f. 6–8,* 1896.
Salix pseudo-Hayei Berry, Bull. Torrey Club, vol. 36: 251, 1909.

Description.—Leaves, small, relatively short and broad, ovate-lanceolate in outline, uniformly about 3 cm. in length, by 1.1 cm. to 1.4 cm. in greatest breadth, which is about half way between the apex and base. Apex acuminate. Base rounded. Margin entire. Petiole short. Midrib slender and slightly curved. Secondaries fine, obscured in some specimens, 5 or 6 pairs, alternate, camptodrome; they branch from the midrib at an angle of about 45° and curve upward.

This species is not uncommon in the Raritan, although Prof. Newberry fails to mention the exact localities from which he collected it. Later, material has come from the lower Raritan, at Milltown. It has been compared with the Dakota group

[1] Hollick, Mon. U. S. Geol. Survey, vol. L., 1907, p. 52.

species, *Salix Hayei* Lesq., and with the Arctic Tertiary, *Salix Ræana*, Heer, both of which it resembles in general appearance, The Dakota group leaf, however, is coriaceous, with a coarse venation, blunt apex and more narrow pointed base, and is seen to be quite different from the Raritan species when careful comparisons are made.

Occurrence.—Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order FAGALES.

Family FAGACEÆ.

Genus QUERCUS Linné.

(Sp. Pl., 1753, p. 994.)

QUERCUS RARITANENSIS Berry.

Quercus Johnstrupi Newb., Fl. Amboy Clays, 69, *pl. 19, f. 7,* 1896 (Non Heer).

Quercus raritanensis Berry, Bull. Torrey Club, vol. 36: 249, 1909.

Description.—Leaves ovate in outline, subcoriaceous, apparently about 8 cm. or 9 cm. in length, by 4.5 cm. in width, pointed above. Margin with coarse pointed teeth separated by rounded sinuses.

The New Jersey occurrence of this species is based on the single obscure fragment of the terminal half of a leaf figured by Prof. Newberry and correlated with *Quercus Johnstrupi* Heer, a Greenland species.

The New Jersey form is obviously not the same as Heer's, which has pointed instead of rounded sinuses, and is a smaller, more *Myrica*-like leaf, with the marginal teeth dentate rather than serrate.

The present species considerably resembles an undescribed *Quercus* from the Cretaceous of North and South Carolina, but this resemblance cannot be construed as a proof of identity

because of the incompleteness of the New Jersey material, consequently the present form is here renamed in allusion to the horizon from which it was collected.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Order URTICALES.

Family ULMACEÆ.

Genus PLANERA Gmelin.

(Syst., vol. II, pt. i, 1891, p. 150.)

PLANERA KNOWLTONIANA Hollick.

Planera Knowltoniana Hollick in Newb., Fl. Amboy Clays, 69, *pl. 42, f. 1–4,* 1896.

Description.—Leaves ovate in outline, broadest toward the base, 2.5 cm. to 5 cm. in length, by 1 cm. to 2 cm. in breadth, with an obtusely pointed apex and a rounded, pointed base. Margin entire below for a short distance, elsewhere coarsely serrate. Midrib thin, somewhat flexuous. Secondaries numerous, 6 to 8 pairs, parallel, fine, not much curved; they branch from the midrib at an acute angle, being either opposite or alternate, and terminate in the marginal teeth. Lateral branches from toward the tips of some of the secondaries terminate in the intervening teeth.

This species is frequent at the Woodbridge locality, but is rather poorly preserved, as is so often the case with the more delicate leaves of the smaller Ulmaceæ. It is very typical of the leaves of this family in general outline, marginal and venation characters, and could be compared with a number of later species of *Planera*. It is quite distinct, however, from the species of *Planera* recently described by the writer from the Bladen formation of North Carolina.[1]

[1] Berry, Bull. Torrey Club, vol. 34, 1907, p. 193, pl. 11, f. 7, 8.

Occurrence.—Woodbridge.
Collections.—N. Y. Botanical Garden.

Family MORACEÆ.

Genus FICUS Linné.

(Sp. Pl., 1753, p. 1059.)

FICUS MYRICOIDES Hollick.

Ficus myricoides Hollick in Newb., Fl. Amboy Clays, 71, *pl. 32, f. 18; pl. 41, f. 8, 9,* 1896; U. S. Geol. Surv., Mon. 50: 57, *pl. 11, f. 8, 9,* 1907 (?) (non-Ward, 1906).

Description.—Leaves narrowly lanceolate in outline, with the maximum dimensions of 2 cm. in width by 10 cm. in length, but sometimes considerably smaller. Margin entire. Apex bluntly rounded. Midrib mediumly stout, straight. Secondaries numerous, about 2 mm. apart, straight and parallel, diverging from the midrib at angles of about 45°, or slightly more, branching to form polygonal areoles near the margin.

This species is not conclusively allied to *Ficus,* nor is it especially well known since the specimens are all fragmentary. It is also recorded by Hollick from Glen Cove, Long Island, and Gay Head, Marthas Vineyard, and by Fontaine and Ward from the Patapsco formation of Maryland. It is probable, however, that some of the remains that have been referred to this species are not related to the type material. This is especially true of the Long Island and Marthas Vineyard leaves which are larger and which suggest to the writer some of the many species of *Magnolia* identified by Dr. Hollick in the insular deposits. The supposed Patapsco occurrence is based on leaf fragments of *Sapindopsis.*

Occurrence.—Milltown.
Collections.—N. Y. Botanical Garden.

FICUS DAPHNOGENOIDES (Heer) Berry.

Plate XII, Fig. 4.

Protoides daphnogenoides Heer, Phyll. Crét. d. Nebr. 17, *pl. 4, f. 9, 10,* 1866.

Lesq., Cret. Fl., 85, *pl. 15, f. 1, 2,* 1874; Fl. Dakota Group, 90, 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 11:98, *pl. 3, f. 1, 2,* 1892; Ibid., vol. 12:36, *pl. 2, f. 4, 9, 13,* 1893; Bull. Torrey Club, vol. 21:52, *pl. 177, f. 1,* 1894; U. S. Geol. Surv., Mon. 50:59, *pl. 12, f. 1–5,* 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (determined by Ward).

Newberry, Fl. Amboy Clays, 72, *pl. 17, f. 8, 9; pl. 32, f. 11, 13, 14; pl. 33, f. 3; pl. 41, f. 15,* 1896.

Gould, Am. Jour. Sci. (IV), vol. 5, 175, 1898 (determined by Ward).

Berry, Bull. N. Y. Bot. Garden, vol. 3:74, *pl. 51, f. 6–9,* 1903.

Ficus proteoides Lesq., Fl. Dakota Group, 77, *pl. 12, f. 2,* 1892.

Ficus daphnogenoides Berry, Bull. Torrey Club, vol. 32:327, *pl. 21,* 1905; Ibid., vol. 33:173, *pl. 7, f. 5,* 1906; Ibid., *vol.* 34:194, *pl. 11, f. 10, 11,* 1907.

Eucalyptus ? attenuata Newb., Fl. Amboy Clays, *pl. 16, f. 5* (non *f. 2, 3*) 1896.

Description.—"Les feuilles sont coriaces, à la base atténuées, entières; la nervure médiane est forte; elle porte deux nervures secondaires faibles, acrodromes, qui sont presque paralléles au limbe; mais elles ne sont pas opposées, comme chez les Daphnogene et Cinnamomum." Heer, 1866.

This species was described by Heer from the Dakota group of Nebraska and was based upon very incomplete material. His specimens have some long ascending secondaries, but Lesquereux's more complete specimens from the same horizon and region show that these secondaries were not acrodrome, but camptrodone. The species in this feature and also in other

respects differs from *Protea* and its allies, which are more coriaceous, with the secondaries branching at acute angles and massed toward the often-apetiolate base. Compared with the genus *Ficus,* it is found to closely resemble a number of different species from such widely separated localities as Central and South America and the Celebes. Especially among the Mexican and Central American forms are very similar leaves seen, e. g., *Ficus fasciculata* Watson, *Ficus lancifolia* Hook and Arn., *Ficus ligustrina* Kunth and Bouché and *Ficus sapida* Miq., especially the latter, which has much the same outline and consistency, the same prominent midrib and the same venation. Placed in the genus *Ficus* where these fossil forms properly belong, they find their affinity in the group which includes, among others, such species as *Ficus elongata* Hosius, *Ficus Berthoudi* Lesq., *Ficus suspecta* Velen., *Ficus Krausiana* Heer, etc.

This species has been found to be quite variable in size, ranging in length from 11 cm. to 22 cm. and in breadth from 1.9 cm. to 3.7 cm. It is usually widest in the lower half of the leaf, although sometimes the base is quite narrow and the widest part is toward the middle. In all unequivocal material the upper half of the leaf is narrow and is produced as a long, slender, often recurved tip, which is one of the characteristic features of the species.

It is a widespread and common form ranging from Marthas Vineyard to Alabama in Eastern North America, and from Northwest Territory to Kansas and Nebraska in the west, and serves to ally the Raritan formation with somewhat later beds elsewhere.

Occurrence.—Sayreville, Woodbridge, Milltown, South Amboy.

Collections.—U. S. National Museum, N.Y. Botanical Garden.

FICUS OVATIFOLIA Berry.

Pate XII, Fig. 3.

Ficus ovata Newb., Fl. Amboy Clays, 70, *pl. 24, f. 1–3,* 1896.
Ficus Woolsoni Berry, Bull. Torrey Club, vol. 34: 194, *pl. 12, f. 1,* 1907.
Ficus ovatifolia Berry, Bull. Torrey Club, vol. 36: 253, 1909.

Description.—Leaves ovate in outline, 8 cm. to 13 cm. in length by 4 cm. to 7 cm. in breadth, petiolate. Apex extended, acute. Base rounded or somewhat descending. Margins entire. Principal veins 3, from the base, the midrib being the stoutest and slightly flexuous. The lateral veins diverge at angles of about 45° and curve upward, traversing somewhat more than the basal half of the leaf and connecting with branches from the lowest pair of camptodrome secondaries of which there are several alternating pairs which branch from the midrib at a wider angle. The laterals give off on the outside 8 to 10 camptodrone veins. Quadrangular areoles formed by nearly straight transverse nervilles fill all of the intervening space.

This species is very close to the same author's *Ficus Woolsoni*, which is a much less elongated comparatively broader leaf, often with a cordate base in consequence.

The very appropriate name *ovata* is antedated by *Ficus ovata* Don (1802–03), so that it becomes necessary to rename the Raritan species.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

Ficus Woolsoni Hollick.

Plate XII, Figs. 1, 2.

Ficus Woolsoni Hollick, Trans. N. Y. Acad. Sci., vol. 12: 33, *pl. 2, f. 1, 2c*, 1892; Ann. N. Y. Acad. Sci., vol. 11: 419, *pl. 37, f. 9*, 1898; U. S. Geol. Surv., Mon. 50: 59, *pl. 11, f. 5, 6*, 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 70, *pl. 20, f. 3; pl. 23, f. 1–6*, 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 74, *pl. 47, f. 7*, 1903; Bull. Torrey Club, vol. 33: 172, 1906; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906.

Description.—Leaves broadly ovate to cordate in outline, 7 cm. to 10 cm. in length by 6 cm. to 10 cm. in breadth, with an acute apex and a cordate to a rounded slightly decurrent base. Margin entire. Principal veins 3, the midrib being the stoutest. The laterals branch at a wide angle from the top of the petiole, traversing considerably more than the basal half of the leaf and joining the camptodrome secondaries above; they give off on the outside numerous camptodrome branches, the lowest of which sometimes branch from their extreme base, giving basal fragments of these leaves the appearance of *Hedera primordialis* Sap.

As previously pointed out, this species has many points of resemblance to the preceding one, but is decidedly shorter and broader, with a more orbicular outline and a marked tendency toward a cordate base. It was evidently of a more coriaceous texture since the finer venation is obsolete.

It is a much more abundant form in the Raritan formation and enjoys a considerable outside distribution, being recorded from Staten Island and from the Tuscaloosa formation in Alabama. It is also present in the Magothy formation. Both this and the preceding represent a type of *Ficus* very abundant in the Upper Cretaceous of the Western Interior region of the United States.

Occurrence.—Sayreville, Woodbridge, Hylton Pits.

Collections.—N. Y. Botanical Garden.

Order PROTEALES.

Family PROTEACEÆ.

Genus PERSOONIA Swartz.

(Trans. Linn. Soc. Lond., vol. IV, 1798, p. 215.)

PERSOONIA SPATULATA Hollick.

Persoonia spatulata Hollick in Newb., Fl. Amboy Clays, 71, *pl. 42, f. 14,* 1896.

Description.—Leaf obovate-spatulate in outline, with an entire margin, 3.4 cm. in length, by about 1 cm. in breadth, widest to-

ward the broadly rounded apex and tapering downward to the cuneate base. Midrib slender. Secondaries numerous, close, fine, branching from the midrib at an acute angle which is very narrow in the basal part of the leaf, nearly straight and comparatively long, apparently camptodrome.

This species was based on the single specimen figured by its author and no additional material has since come to light. It seems to be generically identical with *Persoonia Lesquereuxii* Knowlton, a much commoner form which is relatively shorter and broader and of a less delicate texture and habit. Its relation to the genus *Persoonia* is entirely problematical.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Persoonia Lesquereuxii Knowlton.

Plate XX, Fig. 6.

Persoonia Lesquereuxii Knowlton in Lesq., Fl. Dakota Group, 89, *pl. 20, f. 10–12,* 1892.

Newb., Fl. Amboy Clays, 71, *pl. 42, f. 16,* 1896.

Berry, Bull. Torrey Club, vol. 33: 173, 1906.

Andromeda latifolia Newb., Fl. Amboy Clays, 120 (pars.), *pl. 33, f. 9,* 1896 (non *f. 6–8, 10*).

Description.—Leaves obovate in outline, with a broadly rounded apex, sub-emarginate in one of the Dakota group specimens, gradually narrowing to the decurrent base. Varying from 1.7 cm. to 5 cm. in length by 1.2 cm. to 2.5 cm. in greatest width, which is toward the apex. Petiole stout. Texture subcoriaceous. Secondaries sparse, 3 or 4 pairs, thin, alternate, branching from the stout midrib at an acute angle, about 25°, camptodrome.

This species, which was described originally from the Dakota group, of Kansas, is somewhat variable in appearance. Hollick referred a small almost orbicular leaf from the New Jersey Raritan to it, presumably on the basis of its resemblance to Knowl-

ton's fig. 12. For the same reason the writer is inclined to think that Newberry's pl. 33, fig. 9, which he calls an *Andromeda,* is also referable to this species. Similar obovate leaves are also present in the overlying Magothy formation.

Professor Newberry left no indication of the locality in the Raritan from which this species was collected. It is, however, present in subsequent collections from South Amboy.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order RANALES.

Family RANUNCULACEÆ (?).

Genus DEWALQUEA Sap. and Mar.

(Essai Végét Marnes Heersiennes de Gelinden, 1874, p. 55.)

DEWALQUEA GROENLANDICA Heer.

Dewalquea groenlandica Heer, Fl. Foss. Arct., vol. 6, Ab. 2: 87, *pl. 29, f. 18, 19; pl. 42, f. 5, 6; pl. 44, f. 11,* 1882; Ibid., vol. 7: 37, *pl. 62, f. 5, 6,* 1883.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 129, *pl. 41, f. 2, 3,* (non *f. 12*), 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 423, *pl. 36, f. 7,* 1898; U. S. Geol. Survey, Mon. 50: 106, *pl. 8, f. 25,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 98, *pl. 57, f. 3,* 1903; Bull. Torrey Club, vol. 34: 194, 1907.

Description.—"D. foliis digitato-trifoliolatis, foliolis lanceolatis, integerrimis, basim versus sensim attenuatis; nervo medio valido, nervis secundariis angulo perecuto egredientibus, valde curvatis." Heer, 1882.

The two type figures from Kardlok, Greenland, have very much elongated attenuated bases and the leaflets reach a width of

2.2 cm. While their distal portions are broken off they were apparently 12 cm. or 13 cm. in length. Subsequently, remains of a similar nature from elsewhere in Greenland were referred by Heer to this species, among them, the only complete leaf (loc. cit. pl. lxii, fig. 6) which shows a blunt apex. It is with this latter specimen that the Raritan leaves show the most marked affinity. The latter are found detached, but are unsymmetrical, as is the case with the leaflets of many trifoliate forms. They have a rather slender midrib and 6 or 8 pairs of very thin ascending camptodrome secondaries, the apex is blunt and the base is attenuated. They are about 7 cm. in length by 1.4 cm. to 1.7 cm. in greatest width. There seems to be little room for doubt but that they are correctly identified.

This species has a wide range, if reliance can be placed on the published records, which include Staten Island, North Carolina and Alabama.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

DEWALQUEA TRIFOLIATA Newb.

Dewalquea trifoliata Newb., Fl. Amboy Clays, 129, *pl. 22, f. 4–7,* 1896.

Description.—Leaves trifoliate. Leaflets linear lanceolate. While the tips are missing on all of the specimens the apex was apparently acuminate. Base cuneate and decurrent, in some instances continued downward and joining that of its fellow leaflets, inequilateral in the lateral leaflets. Size variable, ranging from about 8 cm. to 12 cm. in length and 1.2 cm. to 2 cm. in breadth. Margins entire throughout. Midrib medium, slightly flexuous. Secondaries numerous, thin, more or less obsolete, apparently camptodrome.

A number of specimens, all incomplete, have been collected from the Woodbridge clays and several are figured in Prof. Newberry's monograph. The genus is characteristic of the Upper Cretaceous and Lower Eocene and its botanical affinities are still considered doubtful, although it is usually classed with

the Ranunculaceæ following the views of Saporta and Marion, who handled a large amount of fine material from the Heersian of Belgium.

The present species has not been recognized outside of the Raritan formation and is perfectly distinct from the wide ranging *Dewalquea groenlandica* Heer.

Occurence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family MAGNOLIACEÆ.

Genus MAGNOLIA Linné.

(Sp. Pl., 1753, p. 535.)

MAGNOLIA SPECIOSA Heer.

Plate XIV, Fig. 3.

Magnolia speciosa Heer, Neue Denks. Schw. Gesell, vol. 23: 20, *pl. 6, f. 1; pl. 9, f. 2; pl. 10, f. 1,* 1869.

Lesq., Cret. & Tert. Fl., 72, 1874; Fl. Dakota Group, 202, *pl. 60, f. 3, 4,* 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 234, *pl. 7, f. 4,* 1893; Bull. Torrey Club, vol. 21: 60, *pl. 178, f. 5,* 1894; Bull. Geol. Soc. Amer., vol. 7: 13, 1895; U. S. Geol. Surv., Mon. 50: 64, *pl. 19, f. 1–4,* 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Knowlton, 21 Ann. Rept. U. S. Geol. Surv., pt. 7, 318, 1901.

Berry, Bull. Torrey Club, vol. 31: 76, *pl. 3, f. 10,* 1904; Ibid., vol. 32: 46, *pl. 2, f. 4, 5,* 1905.

Magnolia auriculata Newb., Fl. Amboy Clays, 75 (pars.), *pl. 41, f. 13; pl. 58, f. 10,* 1896.

Description.—"M. foliis maximis, coriaceis, ovato-ellipticis, apice longe attenuatis, valde acuminatis, basi in petiolum validum attenuatis, nervo primario crasso, nervis secundariis valde curvatis, camptodromis." Heer, 1869.

This species is somewhat variable in size, the American material which is somewhat smaller than the type material from

Moletein, Moravia, ranging in length from 8.5 cm. to 19 cm., and in width from 4 cm. to 7.5 cm. It is ovate-elliptical in outline with the apex more or less produced and the base decurrent. The midrib and petiole are stout. The secondaries are well marked, camptodrome; they number 7 to 9 pairs, and are subopposite, branching from the midrib at an angle of about 45° and curving upward. The texture is coriaceous.

This species, which was described originally from the Cenomanian of Moravia, has been found to have a wide range in America. Typical leaves occur in the Dakota Group which range southward to Texas. It is present on Marthas Vineyard and Long Island, and in the Magothy formation of New Jersey. While not heretofore reported from the Raritan it would seem as if some of the leaves which Prof. Newberry described as *Magnolia auriculata* should be referred to this species. They range down in size, but this is also true of some of the western leaves of this species. *Magnolia auriculata* was reported by Prof. Ward from the Tuscaloosa formation of Alabama, but all of the specimens so labelled, which have come into the writer's hands for study, are closer to *Magnolia speciosa*, and not one shows any tendency toward an auriculate base which is the main characteristic of the former species. This may, of course, have been a variable feature, as it is to a certain extent in the existing *Magnolia Fraseri* Walt., and *Magnolia macrophylla* Michx., but if it is worth anything at all in the fossils it is worth emphasizing. This is another species which tends to correlate the Raritan with the Cenomanian of Europe.

Occurrence.—Woodbrige.

Collections.—N. Y. Botanical Garden.

MAGNOLIA ALTERNANS Heer.

Plate XV Fig. 1.

Magnolia alternans Heer, Phyll. Crét. d. Nebr., 20, *pl. 3, f. 2–4; pl. 4, f. 1, 2,* 1866; Fl. Foss. Arct., vol. 3, ab. 2: 116, *pl. 33, f. 5, 6; pl. 34, f. 4,* 1874; Ibid., vol. 6, ab. 2: 91, *pl. 21, f. 2; pl. 46, f. 21,* 1882.

Lesq., Cret. Fl., 92, *pl. 18, f. 4*, 1874; Fl. Dakota Group, 201, *pl. 34, f. 11*, 1892.

Velen., Fl. Böhm. Kreidef. Pt. 2: 19; *pl. 6, f. 5; pl. 7, f. 6*, 1883.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 73, *pl. 55, f. 1, 2, 4, 6*, 1896.

Hollick, U. S., Geol. Surv., Mon. 50: 67, 1907.

Pollard, Trans. N. Y. Acad. Sci., vol. 13: 181, 1894.

Description.—"M. foliis coriaceis, petiolatis, ellipticis, integerrimis, basi in petiolum attenuatis, nervis secundariis angulo acuto egredientibus, valde curvatis, camptodromis, alternis tenuioribus." Heer, 1866.

This is a rather poorly defined species whose wide range is based for the most part upon very fragmentary material. It is oblong elliptical in outline, 9 cm. to 15 cm. in length by 3 cm. to 7 cm. in breadth, with a stout petiole 5 cm. to 7 cm. in length. Apex pointed. Base cuneate to rounded. Midrib stout. Secondaries stout, separated by tertiaries, camptodrome.

This species was described originally from the Atane beds of Greenland, and it has since been reported outside of the New Jersey area from the Cenomanian of Bohemia, the Dakota Group in Nebraska, Kansas and Minnesota, the Tuscaloosa formation of Alabama and the Raritan (?) of Long Island. As previously mentioned, all of the references in the foregoing synonymy cannot be vouched for as regards correctness of identification.

Occurrence.—Sayreville, Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA BOULAYANA Lesq.

Plate XIV, Fig. 2.

Magnolia Boulayana Lesq., Fl., Dakota Group, 202, *pl. 60, f. 2*, 1892.

Knowlton, 21 Ann. Rept. U. S. Geol. Surv., pt. 7: 318, 1901.

Berry, Bull. Torrey Club, vol. 36: 254, 1909.

Magnolia glaucoides Hollick, Bull. Torrey Club, vol. 21: 60, *pl. 175, f. 1, 7*, 1894; U. S. Geol. Surv., Mon. 50: 67, *pl. 19, f. 6; pl. 20, f. 6*, 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 74, *pl. 57, f. 1–4,* 1896.

Description.—Leaves narrowly elliptical in outline, remarkably uniform in size and shape, 8.5 cm. to 13 cm. in length and 3.5 cm. to 4.5 cm. in breadth. Apex usually bluntly rounded, sometimes acute. Base matching the apex. Petiole mediumly stout, 3 cm. to 4 cm. in length. Midrib mediumly stout. Secondaries slender, often obsolete, about 11 pairs, equidistant, parallel, camptodrome, branching from the midrib at an angle of about 40°. Tertiaries when seen transverse. Texture coriaceous.

This species was described originally from the Dakota Group of Kansas. Professor Newberry described the Raritan remains, which are abundant at the Woodbridge locality, as a new species, and it has been kept distinct by Hollick, who recognized, however, its practical identity with the Dakota Group plant.

There can be no question but that they belong to the same species which is also recorded from Marthas Vineyard and Long Island, and from the Woodbine formation of Texas and the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA ISBERGIANA Heer (?).

Magnolia Isbergiana Heer, Fl. Foss. Arct., vol. 6, abth. 2:91, pl. 36, fig. 3, 1882.
Hollick, Bull. Torrey Club, vol. 21:60, 1894. Mon. U. S. Geol. Surv., vol. 50:66, pl. 20, fig. 4, 1907.

Description.—"M. foliis late ovatis, basi rotundatis; nervis secundariis approximatis, angulo acuto egredientibus, curvatis." Heer, 1882.

This species was described by Professor Heer from the Atane beds of western Greenland and compared with that author's *Magnolia Capellinii*, from which it differs in its thinner and more numerous secondaries and its truncated base. It has also been

recorded by Hollick from the Cretaceous at Glen Cove, Long Island.

The material from Milltown is fragmentary, as is the type from Greenland and the single specimen from Long Island, so that it is difficult to determine all of its specific characters. In general the leaf is broadly ovate or subelliptical in outline, with a rounded or bluntly pointed apex and a widely truncated base, rounded laterally. Length, 9 cm. to 12 cm. Greatest width, which is at or near the base, 6 cm. to 10 cm. Midrib comparatively slender. Secondaries, 9 or 10 alternate pairs, very thin, branching from the midrib at an acute angle, camptodrome.

This species remotely resembles *Magnolia Capellinii* as has been pointed out by Heer. It also suggests in its general outline and venation characters *Magnolia Lacoeana* of Lesquereux, differing merely in the character of its base.

Occurrence.—Milltown.

Collections.—U. S. National Museum.

MAGNOLIA NEWBERRYI Berry.

Plate XIII.

Magnolia longifolia Hollick, Trans. N. Y. Acad. Sci., vol. 12: 36, *pl. 3, f. 9,* 1892; Ann. N. Y. Acad. Sci., vol. 11: 422, *pl. 37, f. 3,* 1898; U. S. Geol. Surv. Mon. 50: 66, *pl. 20, f. 2, 3,* 1907 (non Sweet, 1826).

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 76, *pl. 55, f. 3, 5; pl. 56, f. 1–4,* 1896.

Magnolia Newberryi Berry, Bull. Torrey Club, vol. 34: 195, *pl. 13, f. 6,* 1907.

Description.—Leaves mostly of large size, ovate to oblong in outline, about 20 cm. in length by 9 cm. to 10 cm. in breadth, broadest toward the base. Apex sub-acute or obtuse. Base varying from obtusely rounded, almost truncate, to somewhat cuneate. Petiole and midrib stout. Secondaries comparatively thin and open, about 12 pairs, camptodrome. Tertiaries

forming 4, 5, or 6 sided areoles, quite prominent in some specimens.

This is the largest *Magnolia* of the Raritan, the leaves of which are said by Prof. Newberry to reach a length of 30 cm. or more. It is frequent at the Woodbridge locality and has also been reported from Staten Island and Marthas Vineyard, from the Tuscaloosa formation in Alabama and from the Bladen formation in North Carolina.

In a general way it resembles an immense leaf of *Magnolia woodbridgensis,* and it also approaches somewhat *Magnolia longipes,* but the petiole is only about one-third the length that it is in the latter species.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA LACOEANA Lesq.

Plate XVI, Fig. 2.

Magnolia Lacoeana Lesq., Fl. Dakota Group, 201, *pl. 60, f. 1,* 1892.
Newb., Fl. Amboy Clays, 73, *pl. 55, f. 1, 2,* 1896.
Hollick, U. S. Geol. Surv. Mon. 50: 65, *pl. 17, f. 2,* 1907.

Description.—Leaves broadly oval to almost orbicular in outline, obtuse or abruptly pointed above and rounded to a somewhat cuneate below, 10 cm. to 12 cm. in length, by 8.5 cm. to 9.5 cm. in width. Midrib stout, somewhat flexuous. Secondaries numerous, camptodrome, mediumly stout, 10 to 12 pairs; they branch from the midrib at an acute angle, immediately curving outward, forming festoons near the margin, which is somewhat undulate in one specimen which Prof. Newberry referred to this species.

This species differs from its contemporaries, especially in its nearly round outline; Prof. Lesquereux finds a resemblance to *Magnolia Inglefieldi* Heer from Greenland, and it also suggests some of the Arctic forms which have been referred to *Magnolia Capellini* Heer.

While this species is reported from such widely separated points as Marthas Vineyard and Kansas, it is nowhere abundant, and is usually poorly preserved, suggesting that the leaves were readily macerated. It also occurs in unreported collections from the Magothy formation in Maryland.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA LONGIPES Hollick.

Plate XIV, Fig. 1.

Magnolia longipes Hollick, Bull. Torrey Club, vol. 21:60, *pl 178, f. 3,* 1894; U. S. Geol. Surv. Mon. 50:64, *pl. 21, f. 5, 6,* 1907.

Newb., Fl. Amboy Clays, 76, *pl. 54, f. 1–3,* 1896.

Description.—Leaves oblong-ovate in outline, apparently about 18 cm. in length, by 6 cm. or 7 cm. in breadth, which was below the middle. Apex obtusely rounded. Base usually cuneate. Midrib and petiole very stout, the latter unusually long, reaching 12 cm. or 13 cm. in some specimens. Secondaries camptodrome, relatively thin and remote, 10 to 12 pairs, branching from the midrib at an angle of about 45° and soon curving upward to join a branch from the secondary next above. This forms a series of large arches which approximately parallel the margin and constitute one of the distinctive characters of this species, another being the long petiole and the oblong, almost straight-sided, shape.

This was a very striking Magnolia and is frequent in the Raritan at Woodbridge. Fragmentary specimens which have been correlated with these remains are reported from Long Island. It is apparently quite different in appearance from any of the other Cretaceous species of Magnolia, although it suggests somewhat a gigantic form of *Magnolia woodbridgensis.*

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Magnolia woodbridgensis Hollick.

Plate XV, Fig. 2.

Magnolia woodbridgensis Hollick in Newb., Fl. Amboy Clays, 74, *pl. 36, f. 11; pl. 57, f. 5–7,* 1896; Ann. N. Y. Acad. Sci., vol. 11 : 60, *pl. 3, f. 2,* 1898. U. S. Geol. Surv. Mon. 50 : 66, *pl. 20, f. 7,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3 : 77, *pl. 53, f. 5; pl. 57, f. 2,* 1903.

Description.—Leaves elongate-ovate in outline, 10 cm. to 15 cm. in length by 4 cm. to 6 cm. in greatest breadth, which is toward the base. Apex obtuse. Base rounded. Midrib stout. Secondaries slender, numerous, about 12 pairs, camptodrome, branching from the midrib at a wide angle in some instances approaching 90°. The original description says that the texture is thin, although, according to the writer's observations, it is subcoriaceous, and the venation is often obsolete.

This species is common in the Raritan at the Woodbridge locality, and it has also been recorded from Block Island and from the Magothy formation at Cliffwood bluff.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Magnolia Hollicki Berry.

Plate XV, Fig. 3.

Magnolia Hollicki Berry, Bull. Torrey Club, vol. 36 : 253, 1909.

Magnolia auriculata Hollick, Bull. Torrey Club, vol. 21 : 61, *pl. 179, f. 6, 7,* 1894; U. S. Geol. Surv. Mon. 50 : 67, *pl. 19, f. 5; pl. 20, f. 5, 8,* 1907 (non Lam., 1783).

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 75, *pl. 58, f. 1–9, 11,* 1896 (non *f. 10*).

Berry, Bull. Torrey Club, vol. 33 : 174, 1906.

Dicotyledonous leaf impression Hitchcock, Geol. Mass., vol. 2 : 430, *pl. 19, f. 1* (pars), 1841.

Description.—Leaves orbicular-ovate in outline, 4 cm. to 10 cm. in length by 2 cm. to 5.5 cm. in width, petiolate. Apex acute, slightly extended in one or two specimens. Base rounded occasionally, usually pronouncedly auriculate. Petiole and midrib stout. Secondaries few, 6 or 7 pairs, sub-opposite, camptodrome. Texture smooth and subcoriaceous.

This magnificent species is abundant and well preserved at the Woodbridge locality and Marthas Vineyard and in the Magothy formation of Maryland. Prof. Newberry was somewhat uncertain as to its relationship with Magnolia and compared it with *Aristolochia, Polygonum* and *Toxylon.* The latter is the only genus which is at all suggestive, and it furnishes no instances of auriculate bases, while this character of a base prevails in more than one modern species of Magnolia. The outline, consistency and venation, are all in accord in pointing to Magnolia as the proper generic reference. This is one of those forms mentioned from Marthas Vineyard by Prof. Hitchcock in his Geology of Massachusetts published in 1841.

Unfortunately the specific name had been previously used by both Lamarck and Desvaux in 1783 and 1789, so that the fossil species may well be renamed in honor of Dr. Hollick, who has done so much in the elucidation of the Cretaceous floras in the vicinity of New York.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus LIRIODENDRON Linné.

(Sp. Pl., 1753, p. 535.)

LIRIODENDRON OBLONGIFOLIUM Newb.

Liriodendron oblongifolium Newb., Bull. Torrey Club, vol. 14: 5, *pl. 61, f. 1,* 1887; Fl. Amboy Clays, 81, *pl. 52, f. 1–5,* 1896.

Hollick, Bull. Torrey Club, vol. 21: 62, *pl. 179, f. 3,* 1894; U. S. Geol. Surv. Mon. 50: 68, *pl. 21, f. 8,* 1907.

Description.—A considerable variety of forms are referred by Professor Newberry to this species; most of these are fragmentary and depart somewhat from the usual form; for example, his fig. 2 shows the terminal portion of the lobes with several acute marginal teeth. This author's fig. 1 is here taken as the typical form, and it may be described as follows: Leaves oblong in outline, of large size, 11 cm. in length along the midrib by about the same distance in greatest width. Apex emarginate. Base truncate. Laterally there are three or four incipient lobes or points separated by wide, shallow, rounded sinuses, the lowest pair being almost half the distance from the base to the end of the midrib. Petiole long and stout. Midrib stout. Secondaries slender but well marked, numerous, about 12 pairs, sub-opposite, mostly camptodrome, usually sending branches to the marginal points, occasionally one runs direct to a marginal point; they branch from the midrib at a wide angle, about 65°, and are comparatively straight in their courses and consequently approximately parallel.

The remains of this species are rather infrequent and fragmentary, on the whole they indicate a leaf surprisingly like that of the modern tree and almost identical with those modern leaves which are more or less quadrangular in outline, with shallow rounded sinuses and from 2 to 5 marginal lobes on each side.

This species is confined to the Woodbridge locality, with the exception of a single extremely doubtful fragment from Glen Cove, Long Island, which Hollick tentatively identifies with it.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

LIRIODENDRON QUERCIFOLIUM Newb.

Plate XVII, Fig. 1.

Liriodendron quercifolium Newb., Bull. Torrey Club, vol. 14: 6, *pl. 62, f. 1,* 1887; Fl. Amboy Clays, 81, *pl. 51, f. 1–6,* 1896.

Description.—Leaves oblong in general outline, of large size, pinnately divided by narrow sinuses into from 2 to 4 lateral

lobes. Apex emarginato. Base truncate to somewhat cordate. Length along the midrib varying from 7 cm. to 9 cm. and probably considerably greater in some specimens since one fragment measures 12 cm. in width. Width in perfect specimens about 9 cm. Lateral lobes ovate in outline with very acute tips, sometimes narrowed proximad giving them an almost obovate outline; intervening lateral sinuses narrow and deeply cut, in some instances reaching nearly to the midrib, rounded. In some specimens only 2 main lobes are developed on each side, which are then quite similar to the typical modern leaf. In these cases, however, the upper lobes are divided by a shallow sinus into 2 sharp lobules. Other specimens show 3 lobes of equal magnitude on each side, while one of the best specimens has 4 nearly equal lobes on each side, the basal and apical pairs being somewhat shorter than the medial pairs. This form of leaf is very suggestive of some species of *Quercus*, but its variations, as well as its venation, show that it is related to *Liriodendron*. The petiole is preserved for a considerable length and is very stout, as is the midrib. There is one main secondary traversing each lobe and running directly to its apical point. In addition there are one or more camptodrome secondaries in each lobe which anastomose with branches from the main secondary, their number being dependent upon the relative width of the lobe; they branch from the midrib at angles of about 60°.

At first sight this species appears to differ considerably from *Liriodendron oblongifolium* and from the modern form, but this difference is not nearly as great as it seems, and it is probable that *Liriodendron quercifolium* is simply a variation from the common ancestor of the two species in the direction of *Liriodendron pinnatifidum* Lesq. Numerous leaves of the modern tree can be found with an incipient lobation suggesting *Liriodendron quercifolium*. In these, however, the sinus is comparatively shallow and rounded, so that the general appearance of the two is not markedly similar.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family LAURACEÆ.

Genus SASSAFRAS Nees.

(Handb. Bot., vol. ii, 1831, p. 418.)

SASSAFRAS ACUTILOBUM Lesq.

Plate XVIII, Fig. 2.

Sassafras acutilobum Lesq., Cret. Fl., 79, *pl. 14, f. 1, 2,* 1874; Cret. and Tert. Fl., 56, *pl. 5, f. 1, 5,* 1883; Fl. Dakota Group, 100, 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 236, *pl. 7, f. 1,* 1893; U. S. Geol. Surv. Mon. 50: 77, *pl. 30, f. 8, 9,* 1907.

Newb., Fl. Amboy Clays, 87, *pl. 25, f. 1–10; pl. 26, f. 2–6,* 1896.

Kurtz, Revista Mus. La Plata, vol. 10: 53, 1902.

Berry, Bot. Gazette, vol. 34: 438, 1902; Bull. N. Y. Bot. Garden, vol. 3: 81, *pl. 45, f. 1, 2,* 1903; Bull. Torrey Club, vol. 31: *pl. 1, f. 6,* 1904; Ann. Rept. State Geol. (N. J.) for 1905, 139: *pl. 22, f. 4, 5,* 1906.

Description.—Trilobate leaves, variable in size and outline. Length 2.5 cm. (in the young leaves which are preserved at the Woodbridge locality) up to 14 cm., averaging 10 cm. to 12 cm. Width from the tips of the lateral lobes likewise ranging from 1 cm. to 15 cm. averaging about 10 cm. Lobes mostly conical and acute, the middle being usually slightly the broadest and longest. Lateral lobes directed more or less laterally. Base decurrent. The sinuses between the lobes are usually open and rounded, the margins forming an angle of approximately 90°. There is considerable variation, however, in this respect, some of the leaves having comparatively narrow sinuses with the lobes directed upward, as in *Sassafras progentor* Hollick, while others at the opposite extreme of the series, have extremely shallow sinuses, so shallow that the leaf has the appearance of a triangularly pointed, entire leaf. The lateral primaries may branch

from the midrib at or near the base, as they do in a majority of the Raritan forms, or their point of divergence may be a considerable distance above the base, as in modern Sassafras leaves. Their angle of divergence from the midrib varies from about 30° to 40°. The secondaries are usually numerous, regular, camptodrome, and connected by transverse tertiaries, although in the Raritan leaves this uniformity is often lacking. Petiole, stout and long. The marginal vein along the sinus, a marked feature in modern leaves of this genus, is generally wanting in this species, although present in occasional specimens.

This species is apparently widely distributed and almost as variable as the modern Sassafras. Described originally from the Dakota Group as a variety of *Sassafras mudgei*, it occurs, also, on Marthas Vineyard and Long Island and in the Magothy formation of New Jersey and Delaware. It has been recorded from Cerro Guido, Argentina, and Velenovsky identifies somewhat doubtful remains from the Cenomanian of Bohemia as this species. Probable Sassafras fruit has been found in the same strata with *S. acutilobum*[1], tending to show that it is a true Sassafras, notwithstanding its dissimilarities; however, this is not certain, as the leaves and fruit were not found associated. Lesquereux's smallest figure of *S. acutilobum* is considerably smaller, with the lobes directed upward, and is probably a young leaf of his larger form. His other figure approaches some of the leaves which Newberry refers to this species, but has narrower and more produced lobes.

There is considerable doubt as to whether or not the Coastal Plain leaves are generically related to Sassafras. Whether the Dakota group forms are those of Sassafras it is not easy to decide. No modern Sassafras leaves have the primaries and the lateral lobes so nearly horizontal; the secondaries are not so uniformily regular, nor do they curve upward to join the next above at a point. In the modern leaf an outwardly and downwardly directed branch from the latter is emphasized. There is never such an open sinus, amounting as it does to

[1] Lesquereux, Fl. Dakota Group, p. 230.

nearly 90°, and the lobes in the modern leaf have their margins inflated and not straight. In these ancient leaves the sinus seldom has a marginal vein, the secondary in this region usually forking and striding it, or curving to join its neighbor. The secondary system seems to be uniform throughout the leaf, while in the modern leaf there is always evidence of changed conditions in that region around the sinus; the secondaries or their representatives from both the primaries and midrib are changed in size and direction, and usually belong to the tertiary system. None of the Dakota leaves of this species show the characteristic basal venation of the modern leaf. While we should not, necessarily, expect Cretaceous species to conform to the modern type, still the character of the secondary system in the former is so different from what would obtain in a leaf descended from a simple ancestor, such as Sassafras is thought to have done, that we are inclined to associate these leaves with those trilobed forms which have been referred to, *Aralia* or *Sterculia,* laying aside, for the present, any consideration as to whether or no they are true species of *Aralia* and *Sterculia.*

However, in view of the present uncertainty, and because of the havoc to the stratigraphic value of these leaves which would be wrought by any change of name, they are retained in the genus *Sassafras* pending more positive evidence of their affinity.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

SASSAFRAS PROGENITOR Hollick.

Plate XVIII, Fig. 1.

Sassafras progenitor Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 174, f. 1,* 1894; Bull. Geol. Soc. Amer., vol. 7: 13, 1895; U. S. Geol. Surv. Mon. 50: 78, *pl. 30, f. 11,* 1907.

Newb., Fl. Amboy Clays, 88, *pl. 27, f. 1–3,* 1896.

Berry, Bot. Gazette, vol. 34: 443, 1902; Bull. Torrey Club, vol. 31: 78, *pl. 1, f. 3,* 1904.

Description.—Trilobate leaves of variable size, 5 cm. to 20 cm. in length, by 3.5 cm. to 13 cm. in breadth. Lobes pointed or obtuse, the middle one considerably the larger. Petiole short and stout. Primaries branching from the cuneate base at an acute angle. Secondaries remote, camptodrome with the exception of the pair, of which one runs to the sinus on each side.

Prof. Newberry is very positive that this leaf is a true *Sassafras*, with which view I entirely agree. The small leaf is the exact counterpart of the modern Sassafras leaf in outline and venation, with the exception that the primaries are basal. While no marginal veins are visible at the sinuses, the first secondaries leave the midrib and curve upward, running directly to the sinuses as in the existing Sassafras leaves. Hollick's specimen from Long Island, while fragmentary, has a short branch running to the sinus in the half of the leaf-blade which is preserved. Newberry's other figures each lack the basal portion of the blade and one of the lateral lobes; the lobes are more obtuse than in his smaller specimen. While the sinus appears to lack a marginal vein, the disposition of the secondaries and tertiaries in this region is Sassafras-like.

This species is common but fragmentary in the Raritan at Woodbridge, and has also been reported from Long Island and from the Magothy formation of New Jersey. It suggests somewhat *Sassafras Mudgei* Lesq. from the Dakota Group.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

SASSAFRAS HASTATUM Newb.

Plate XVII, Fig. 2.

Sassafras hastatum Newb., Fl. Amboy Clays, 88, *pl. 27, f. 4–6; pl. 28, f. 1, 2; pl. 40, f. 4*, 1896.

Berry, Bot. Gazette, vol. 34: 448, 1902.

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 414, *pl. 79, f. 4*, 1904; U. S. Geol. Surv. Mon. 50: 78, *pl. 29, f. 4; pl. 30, f. 12*, 1907.

Description.—Trilobate leaves more or less hastate in outline. Lobes conical, obtusely pointed, the middle one the larger. The lateral lobes are generally directed horizontally, thus the base is truncate in extreme forms, in others it is broadly rounded, while still other fragments indicate that it was cuneate in some specimens. These leaves vary considerably in size and appearance, some of them approaching *Sassafras progenitor* Hollick in appearance. They are about 10 cm. to 12 cm. in length, by about the same distance from tip to tip of the lateral lobes. Primaries 3, somewhat flexuous, diverging a considerable distance above the base, the short and stout petiole continuing upward in the base of the leaf in undiminished size to this point of divergence. Angle between the lateral primaries and the midrib varying from 32° to 70°, being usually nearer the latter than the former figure. In one specimen there are 2 pairs of laterals below the point of divergence of the primaries.

This species shows considerable diversity of characters. It is quite common at the Woodbridge horizon and is also reported from Long Island and Marthas Vineyard. Its relation to the modern Sassafras is very doubtful and it seems to be allied to some of the Raritan forms which Newberry identifies with *Aralia.*

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus LAURUS Linné.

(Sp. Pl., 1753, p. 369.)

LAURUS PLUTONIA Heer.

Laurus plutonia Heer, Fl. Foss. Arct., vol. vi, ab. 2: 75, *pl. 19, f. 1d, 2–4; pl. 20, f. 3a, 4–6; pl. 24, f. 6b; pl. 28, f. 10, 11; pl. 42, f. 4b,* 1882; Ibid., vol. vii: 30, *pl. 58, f. 2; pl. 62, f. 1a,* 1883.

Velen., Fl. Böhm, Kreidef., Theil 3. p. 1, *pl. 4, f. 2–4,* 1884.

Lesq., Fl. Dakota Group, 91, *pl. 13, f. 5, 6; pl. 22, f. 5,* 1892; Geol. and Nat. Hist. Surv., Minn., vol. 3, pt. 1, p. 14, *pl. A, f. 6; pl. B, f. 5,* 1895.

Newb., Fl. Amboy Clays, 85, *pl. 16, f. 10, 11*, 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. ii: 60, *pl. 4, f. 6, 7*, 1898; U. S. Geol. Surv., Mon. 50: 80, *pl. 27, f. 9, 11; pl. 28, f. 1, 2*, 1907.

?Gould, Amer. Jour. Sci., vol. 5: 175, 1898.

Berry, Bull. N. Y. Bot. Gard., vol. 3: 79, *pl. 50, f. 9–11*, 1903; Bull. Torrey Club, vol. 31: 77, *pl. 3, f. 1*, 1904; Ibid., vol. 33: 178, 1906; Ann. Rept. State Geol. (N. J.) for 1905: 138, 139, 1906.

Description.—"L. foliis subcoriaceis, lanceolatis, utrinque attenuatis, acuminatis, integerrimis; nervo primario validiusculo, nervis secundariis numerosis, tenuibus, sub-angulo acuto egredientibus, arcuatis, interstitiis reticulatis." Heer, 1882.

Leaves lanceolate in outline, usually tapering in both directions, but sometimes less acute at the base. Length 7 cm. to 11 cm.; greatest width 1.5 cm. to 2.5 cm. Midrib mediumly stout. Petiole short and stout, 6 mm. to 15 mm. in length. Secondaries slender, eight or more alternate pairs, camptodrome.

This species was described by Heer from the Atane beds of Greenland, and a large number of somewhat variable and fragmentary specimens were figured. Professor Newberry records specimens from the Raritan formation without giving any specific localities. Those figured show leaves which are relatively wider than the usual leaves of this species, but these are comparable with some of the Greenland material, as, for example, Heer's pl. 20, fig. 5 and pl. 28, fig. 11. Entirely typical leaves occur in the top layers of the Raritan at the Hylton Pits.

Subsequent to its description by Professor Heer this species was recorded from a very large number of Cretaceous plant beds, so that its present range, both geographical and geological, is rather extensive. A number of these records are not entirely above question, and this appears to be especially true of the forms from the Cenomanian of Bohemia, which Velenovsky so identifies.

It is evidently a rare plant in the Raritan, but becomes abundant in the immediately succeeding floras, being common in that of the Dakota Group and in the Magothy formation at a number of localities in New Jersey and Maryland. It is a common form

in the insular Cretaceous floras and also occurs in the South Atlantic Coastal Plain. Supposed fruits are figured by Heer (loc. cit. pl. 42, f. 4b).

Occurrence.—Hylton Pits, Milltown.

Collections.—N. Y. Botanical Garden.

Genus LAUROPHYLLUM Goeppert.

(Tertiärfl. Java, 1854, p. 45.)

LAUROPHYLLUM NERVILLOSUM Hollick.

Laurophyllum nervillosum Hollick, Mon. U. S. Geol. Surv., vol. 50:82, *pl. 27, f. 6, 7,* 1907.

Berry, Bull. Torrey Club, vol. 36:255, 1909.

Proteoides daphnogenoides Hollick, Ann N. Y. Acad. Sci., vol. 11:420, *pl. 36, f. 1, 3,* 1898.

Description.—Leaves of comparatively large size, oblong lanceolate in outline, about 15 cm. in length by about 2.6 cm. in greatest breadth, which is about midway between the apex and base. Apex acuminate. Base pointed, narrowly cuneate. Midrib stout. Secondaries thin, close, parallel, branching from the midrib at angles not exceeding and usually somewhat less than 45°, ascending, nearly straight or somewhat flexuous, connected by transverse nervilles, branching and inosculating near the margin where they merge in the tertiary venation.

This species was described originally from the terminal moraine at Tottenville, Staten Island, and undoubtedly represents transported Raritan materials. Three specimens are contained in the Milltown collection, and the writer has also collected it from somewhat higher horizons south of New Jersey. It is somewhat like *Laurophyllum lanceolatium* Newberry, but has a markedly different venation and a less lanceolate outline. It is also quite close to *Laurophyllum elegans* Hollick, which is, however, a more slender lanceolate leaf, with narrowly produced apex and base and a somewhat coarser venation, with less close and more curved camptodrome secondaries.

Occurrence.—Milltown.

Collections.—U. S. National Museum.

LAUROPHYLLUM ELEGANS Hollick.

Laurophyllum elegans Hollick, Mon. U. S. Geol. Surv., vol. 50: 81, *pl. 27, f. 1–5,* 1907.
Berry, Bull. Torrey Club, vol. 36: 255, 1909.
Laurus plutonia Hollick, Trans. N. Y. Acad. Sci., vol. 11: 99, *pl. 3, f. 3, 4,* 1892; Ibid., vol. 12: 236, *pl. 6, f. 1,* 1893.
Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci., vol. 11: 420, *pl. 36, f. 2,* 1898.

Description.—Leaves elongate-lanceolate in outline, somewhat flexuous, about 12 cm. to 13 cm. in length, by about 2 cm. in greatest width, which is about midway between the apex and the base. From this point narrowing gradually distad into an antennuated, acuminate, usually curved tip and basally into a long, narrowly cuneate base. Midrib stout, stouter than in *Laurophyllum nervillosum* Hollick. Secondaries numerous, usually less close and somewhat coarser than in the latter species; they branch from the midrib at an acute angle below, which becomes more open above the base of the leaf. They are usually more curved than in *L. nervillosum* and more distinctly camptodrome. Tertiaries, transverse throughout.

These leaves were recorded originally by Hollick as *Laurus plutonia,* Heer, and are later compared by the former author with *Laurus angusta* Heer, which latter species they resemble more than they do the former. In outline they are not unlike *Laurophyllum angustifolium,* Newb., from Woodbridge, N. J., but differ decidedly in venation. They are also similar, but quite distinct from *Laurophyllum nervillosum,* Hollick, and *Laurophyllum reticulatum,* Lesq., of the Dakota Group.

The specimens outside of those recorded in the present contribution from New Jersey and those which are as yet unpublished from the region south of New Jersey, are from transported materials associated with the terminal moraine, from which numerous specimens have been collected. Those from Tottenville, Staten Island, are undoubtedly of Raritan age, while

those from Glen Cove may have been originally from the Magothy formation, although they are probably Raritan.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

LAUROPHYLLUM LANCEOLATUM Newb.

Laurophyllum lanceolatum Newb., Fl. Amboy Clays, 87, *pl. 17, f. 1, 12,* 1896.

Description.—Leaves broadly lanceolate in outline and coriaceous in texture. Nine cm. to 15 cm. in length, by 1.8 cm. to 3 cm. in width, the minimum rather than the maximum being the usual dimensions. Apex more extended than the base, obtusely pointed. Base cuneate, acute. Midrib stout, as is the short petiole. Secondaries fine, usually obsolete, 12 to 15 pairs, subequal, alternate, branching from the midrib at an angle of about 45° and curving upward, camptodrome. Leaf surface noticeably smooth.

This species, which came originally from the Woodbridge locality, where it is common, is equally common at Milltown. It appears to be confined to the New Jersey Raritan, and suggests somewhat the leaves which have been referred to *Laurus plutonia* Heer, from which it may be distinguished in the absence of venation by its texture.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

LAUROPHYLLUM ANGUSTIFOLIUM Newb.

Laurophyllum angustifolium Newb., Fl. Amboy Clays, 86, *pl. 17, f. 10, 11,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 80, *pl. 47, f. 1, 5, 8; pl. 49, f. 1–5.* 1903; Bull. Torrey Club, vol. 33: 178, 1906.

Description.—Leaves elongate-lanceolate, very symmetrical in outline, 10 cm. to 15 cm. in length by 1.5 cm. to 2 cm. in width, widest above the middle, tapering with almost straight sides to the elongate-acute base. Apex narrowed, subacute. Petiole short and stout. Midrib also stout. Secondaries fine, often obsolete, 12 to 15 pairs, branching from the midrib at an angle of about 45° and curving upward, camptodrome. Texture subcoriaceous.

This species which was described from the Woodbridge locality, where it is common, has also been found in the overlying Magothy formation in both New Jersey and Maryland. In the absence of complete and well-marked specimens it is often difficult to differentiate it from contemporaneous species of other genera with similar lanceolate leaves.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

LAUROPHYLLUM MINUS Newb.

Laurophyllum minus Newb., Fl. Amboy Clays, 86, *pl. 16, f. 7–9,* 1896.

Description.—Leaves elongate-lanceolate, 8.5 cm. to 13 cm. in length by 1.6 cm. to 2.3 cm. in width, with an obtuse summit and a cuneate or somewhat obtuse base, occasionally decurrent. Substance very thick and coriaceous. Petiole and midrib very stout, the former longer than in most species referred to this genus. Secondaries invariably obsolete.

This is the least well-defined species of *Laurophyllum* in the Raritan formation and may represent leaf variations of some of the other species. It also suggests the leaves which Heer describes from Greenland as *Myrica longa.*

It was said to be "not uncommon" by Prof. Newberry, although he failed to enumerate any specific localities. Later collections from South Amboy contain several specimens.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Genus CINNAMOMUM Blume.

Cinnamomum Newberryi Berry.

Plate XVI, Fig. 3.

Cinnamomum intermedium Newb., Fl. Amboy Clays, 89, *pl. 29, f, 1–8, 10*, 1896 (non Ettingshausen).

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Berry, Ann. Rept. State Geol. (N. J.) for 1905: 139. *pl. 20, f. 2–6*, 1906; Bull. Torrey Club, vol. 33: 179, *pl. 7, f. 3, 4*, 1906.

Hollick, U. S. Geol. Surv. Mon. 50: 74, *pl. 29, f. 7; pl. 30, f. 1, 2*, 1907.

Cinnamomum sezannense Wat., Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 180, f. 5, 7*, 1894; Ann. Rept. N. Y. State Mus., 55th: A 50 (1901) 1903.

Description.—Leaves ovate-lanceolate in outline, 7 cm. to 12 cm. in length by 2.3 cm. to 4 cm. in width. Apex usually obtusely pointed, sometimes acute. Below narrowed to an acute base. Petiole stout. Venation stout. Primaries 3, the laterals diverging at an acute angle usually some distance above the base and traversing at least more than half the distance to the tip. Secondaries in the upper half of the leaf, 3 or 4 pairs, alternate, camptodrome. The laterals give off numerous camptodrome branches on the outside.

This species is quite common in the Raritan formation at nearly all of the fossiliferous localities and it also has a considerable outside range extending eastward on Long Island and southward in Delaware, Maryland and Alabama. A very similar leaf which is widely distributed in the Cenomanian of Bohemia is identified by Velenovsky[1] as *Aralia daphnophyllum.*

Cinnamomum Heeri was reported from the Raritan at South Amboy by Professor Lesquereux in the 1878 clay report, but it seems probable that this determination was based on specimens

[1] Velenovsky, Fl. Böhm. Kreidef. 1: 30, pl. 7, f. 5–8, 10; pl. 8, f. 1–5, 1882.

of *Cinnamomum Newberryi* since the former species has never been encountered in Raritan deposits either during the progress of Professor Newberry's or the writer's investigations. This species is present, however, in the succeeding Magothy formation. It is a broader leaf with a more rounded base and more prominent primaries. The two species are closely allied, but seem to be abundantly distinct.

The well known name for the present species proposed by Professor Newberry was already in use for a different fossil species described some years earlier by Baron Ettingshausen, hence it becomes necessary to rename the New Jersey species, and the foregoing name is suggested in honor of Professor Newberry.

Occurrence.—Sayreville, Woodbridge, South Amboy, Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Family MENISPERMACEÆ.

Genus MENISPERMITES Lesquereux.

(Cret. Fl., 1874, p. 94.)

MENISPERMITES BOREALIS Heer.

Plate XVIII, Fig. 4.

Menispermites borealis Heer, Fl. Foss. Arct., vol. 6, ab. 2: 91, *pl. 39, f. 2,* 1882.
Newb., Fl. Amboy Clays, 84, *pl. 50, f. 1–6,* 1896.

Description.—"M. foliis magnis, ovato-ellipticis, integerrimis, quinque-nerviis." Heer, 1882.

The type of this species is a single large fragment of an unsymmetrical leaf from the Atane beds of Greenland. Professor Newberry's material from New Jersey is more abundant, but not complete enough for a proper diagnosis. It may be described as follows: Leaves markedly unsymmetrical, ovate-elliptical in outline, about 10 cm. to 15 cm. in length by 6 cm. to

8 cm. in greatest breadth, which is toward the base. Apex obtusely pointed, seldom preserved. Base varying from cuneate to truncate or somewhat cordate. Venation palmate, principal veins said by Heer to be five in number, although only a midrib and two laterals on one side are shown in his figure. The Raritan leaves usually have four veins, two laterals on the convex side and one on the straight side; they diverge from the base and are not so stout as the midrib. Margins entire. Venation camptodrome, more or less obsolete.

This species is somewhat suggestive of *Menispermites obtusiloba* Lesq. of the Dakota Group, with which Professor Heer compared it. The latter is, however, a much more symmetrical leaf, larger in size, with undulate margins and a tendency toward a trilobate form. The fact that the laterals in the New Jersey material are camptodrome might prevent its inclusion in this genus were it not for the fact that the author of the genus also included *camptodrome* forms in it, as, for example, *Menispermites grandis* Lesq., *Menispermites ovalis* Lesq., and *Menispermites cyclophyllum* Lesq.

Occurrence—Woodbridge.

Collections.—N. Y. Botanical Garden.

MENISPERMITES WARDIANUS Hollick.

Plate XVIII, Fig. 3.

Menispermites Wardianus Hollick, in Newb., Fl. Amboy Clays, 85, *pl. 29, f. 9, 11,* 1896.

Description.—Leaves ovate in outline, unsymmetrical, with an acute apex and a cuneate base, 8 cm. to 9 cm. in length by about 4 cm. in greatest breadth, which is about midway between the base and the apex. Margin entire. Midrib mediumly stout, curved nearer the shortest margin. Two lateral primaries diverge at an acute angle from its base and a fourth vein of lesser calibre diverges at the same point and approximately parallels the more convex of the two margins. Tertiary venation obsolete.

These leaves were referred to *Menispermites* by their describer because of their unsymmetrical outline in accordance with Prof.

Newberry's views, although many students will be disposed to question this relationship. The exact locality from which they were collected was not recorded, and no additional specimens have been discovered in subsequent collections, so that our knowledge of the species must remain incomplete, especially as the available material is imperfect.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Order ROSALES.

Family LEGUMINOSÆ.

Genus LEGUMINOSITES Bowerbank.

(Foss. Fr. & Seeds London Clay, 1840, p. 124.)

LEGUMINOSITES CORONILLOIDES Heer.

Leguminosites coronilloides Heer, Fl. Foss. Arct., vol. 3, ab. 2: 119, *pl. 34, f. 14,* 1874.
Lesq., Fl. Dakota Group, 149, *pl. 13, f. 10,* 1892.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 48,* 1896.
Hollick, U. S. Geol. Surv. Mon. 50: 86, *pl. 32, f. 16, 17,* 1907.
Leguminosites frigidus Hollick, Trans. N. Y. Acad. Sci., vol. 12: 34, *pl. 2, f. 11,* 1892.
Colutea coronilloides Heer, Fl. Foss. Arct., vol. 6, ab. 2: 100, 1882.

Description.—"L. foliolis parvulis, ovalibus, breviter petiolatis, nervis secundariis distantibus, curvatis, subtilissimus." Heer, 1874.

Leaflets small, oval in outline, unsymmetrical, 1.5 cm. to 2.8 cm. in length by 8.5 mm. to 12 mm. in breadth, entire, short petioled. Midrib stout. Secondaries thin, remote, 3 to 5 pairs, alternate, camptodrome, often obsolete.

Leguminous leaflets from a number of widely removed localities have been referred to this species, and while all of these are very similar in general characters, their positive identity cannot be affirmed with any great confidence. Described originally from

the Atane beds, they have been detected by Lesquereux in the Dakota Group, by Newberry in the Raritan, by Hollick at Marthas Vineyard and Staten Island and by the writer from Maryland. They are very similar to other species of Leguminosites, as, for example, *Leguminosites frigidus* Heer[1] described from the Patoot beds.

Prof. Heer in his last report (loc. cit.) refers this form to the genus *Colutea,* but it does not seem wise to follow him in this reference with no more evidence than is available. Prof. Newberry unfortunately neglected to record the exact locality for the Raritan material and no additional specimens have been obtained.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES ATANENSIS Heer.

Leguminosites atanensis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 119, *pl. 34, f. 6,* 1874.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 40,* 1896.

Description.—"L. foliolis firmis, oblongis, crassinerviis." Heer, 1874.

Leaflets, elliptical in outline, 3 cm. to 4 cm. in length, by 1.5 cm. to 1.9 cm. in breadth. Margins entire. Apex evenly rounded. Base cuneate. Petiole present, 3 to 5 mm. in length, stout. Midrib stout. Secondaries, 6 or 7 pairs, subopposite, branching at angles varying from 50° to 60°, camptodrome.

This well-marked leaflet, if it is a leaflet, was described from the Atane beds of Greenland, by Prof. Heer, and is represented in the Raritan by a single complete specimen, which is somewhat smaller than the type, but otherwise identical with it, except that the secondaries are straighter and do not clearly show camptodrome characters. There is some resemblance to *Myrsine oblongata* Hollick, from the same beds. Prof. Newberry failed

[1] Heer, Fl. Foss. Arct., 7: 44, pl. 55, f. 21, 22; pl. 65, f. 13, 1883.

to indicate any specific locality and no additional specimens have since been obtained in the New Jersey area.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES OMPHALOBIOIDES Lesq.

Leguminosites omphalobioides Lesq., Fl. Dakota Group, 149, *pl. 38, f. 4,* 1892.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 39,* 1896.

Description.—Leaflets, elliptical in outline, 3.2 cm. to 4 cm. in length, by 1.5 cm. to 1.7 cm. in greatest breadth, which is about half way between the apex and the base. Texture subcoriaceous. Apex rather broadly rounded. Base slightly narrowed and decurrent to the point of attachment. Lesquereux speaks of a short petiole, but this is lacking in his type figure and in all the specimens examined by the writer. The midrib is not especially wide, but is quite prominent. The secondaries are thin and alternate; they number about six pairs, and branch from the midrib at angles of 50° or somewhat less, curving upward close to the margins, camptodrome.

This species was described originally from the Dakota Group of Kansas. The Raritan leaf is very close to the type, differing merely in that the outline is more nearly elliptical than it is in the western form. Prof. Newberry failed to record the locality from which his specimens were obtained and no subsequent material has come to light from the New Jersey clays.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES RARITANENSIS Berry.

Plate XX, Fig. 5.

Leguminosites raritanensis Berry, Bull. Torrey Club, vol. 36: 257, *pl. 18, fig. 4,* 1909.

Description.—Leaflets large, 7.5 cm. by 5.1 cm., almost a perfect ellipse in outline, slightly emarginate at the apex; midrib thin and straight; secondaries numerous, nearly straight, ascending at an angle of about 45°, camptodrome, of delicate calibre and scarcely discernable.

This species is based upon a single individual and seems properly referable to this genus. In outline it suggests some of the forms which have been referred to *Populus,* but its venation is quite different. It also resembles some of the specimens referred to *Liriodendropsis,* which is simply another way of emphasizing the fact that it is a leguminous leaflet of unknown generic affinities.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Genus COLUTEA Linné.

(Sp. Pl., 1753, p. 723.)

COLUTEA PRIMORDIALIS Heer.

Plate XX, Fig. 4.

Colutea primordialis Heer, Fl. Foss. Arct., vol. 6, ab. 2: 99, pl. *27, f. 7–11; pl. 43, f. 78,* 1882.

Lesq., Fl. Dakota Group, 148, *pl. 13, f. 8, 9,* 1892.

Hollick, Bull. Torrey Club, vol. 21: 56, *pl. 174, f. 2,* 1894; U. S. Geol. Surv., Mon. 50: 84, *pl. 32, f. 14, 15,* 1907.

Newb., Fl. Amboy Clays, 97, *pl. 19, f. 4, 5,* 1896.

Description.—"C. foliolis membranaceis, breviter petiolatis, pollicaribus, ovalibus, integerrimis, basi attenuatis, apice profunde emarginatis; nervis secundariis subtilissimis, camptodromis." Heer 1882.

Newberry's specimens from Woodbridge, if they are referable to this species at all, are abnormal or possibly incomplete since the base is much unlike the usual leaves of this species. A typical specimen, however, has been found at South Amboy (Allen pit).

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Genus LIRIODENDROPSIS Newberry.

(Fl. Amboy Clays, 1896, p. 82.)

LIRIODENDROPSIS RETUSA (Heer) Hollick.

Plate XIX, Fig. 1.

Sapotacites retusa Heer, Fl. Foss. Arct., vol. 7: 32, *pl. 61, f. 10,* 1883.
Newb., Fl. Amboy Clays, 123, *pl. 53, f. 5, 6,* 1896.
Liriodendron simplex Hollick, Trans. N. Y. Acad. Sci., vol. 12: 235, *pl. 5, f. 5,* 1893.
Liriodendropsis retusa Hollick, U. S. Geol. Surv. Mon. 50: 72, *pl. 25, f. 8, 9,* 1907.

Description.—"S. foliis oblongo-ovatis, basi attenuatis, apice leviter emarginatis, integerrimis, nervo medio debili, secundariis subtilissimis." Heer 1883.

These leaves are oblong-ovate in outline, with a decidedly emarginate rather than a retuse apex. They are 6 cm. to 8.2 cm. in length by 2.8 cm. to 3.3 cm. in greatest breadth, which is toward the full, cuneate base. Petiole short and reasonably stout. Secondaries mostly obsolete, apparently numerous, slightly curved, parallel.

Prof. Newberry was quite positive that these leaves were different from those which he referred to *Lirodendropsis,* although he compared them to *Liriodendropsis simplex* as well as to *Liriodendron Meekii* Heer and various forms of *Leguminosites* He thought that the angular apical points served to distinguish *Liriodendropsis simplex,* but this character is far from constant in the abundant Long Island material.

The type material came from the Patoot beds of Greenland, and this species is also recorded from Glen Cove, Long Island, as well as Woodbridge, N. J.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

LIRIODENDROPSIS SIMPLEX (Newb.) Newb.

Plate XIX, Fig. 2.

Liriodendron simplex Newb., Bull. Torrey Club, vol. 14: 6, *pl. 62, f. 2, 3,* 1887 (pars).
White, Am. Jour. Sci., vol. 39: 98, *pl. 2, f. 6, 7,* 1890.
Uhler, Trans. Md. Acad. Sci., vol. 1: 207 (1892) 1901.
Hollick, Trans. N. Y. Acad. Sci., vol. 11: 99, *pl. 2, f. 2, 4, 5, 7, 9,* 1892; Ibid., vol. 12: 235, *pl. 5, f. 1, 2, 4; pl. 7, f. 2,* 1893; 55th Ann. Rept. N. Y. State Mus. r50, 1903.
Pollard, Trans. N. Y. Acad. Sci., vol. 13: 180, 1894.
Liriodendropsis simplex Newb., Fl. Amboy Clays, 83, *pl. 19, f. 2, 3; pl. 53, f. 1–4, 7,* 1896.
Smith, Geol. Coastal Plain in Ala., 348, 1894. (nomen nudum.)
Hollick, U. S. Geol. Surv. Mon. 50: 72, *pl. 23, f. 1–7; pl. 24, f. 1–9; pl. 25, f. 1, 4, 5, 7, 10–12; pl. 26, f. 1b, c, d,* 1907.

Description.—Leaves or leaflets ovate to ovate-lanceolate in outline, with entire margins, emarginate apex and cuneate base, varying from 5 cm. to 10 cm. in length, and from 3 cm. to 5 cm. in breadth. Midrib, stout. Secondaries stout, numerous, camptodrome; their intervals filled by more or less parallel, reticulating fine tertiaries. The angles of divergence are variable even in the same leaf, and the exigencies of preservation obscure the finer venation in some specimens, which give them a strikingly different appearance from others in which the preservation is more complete.

These leaves are very variable in size and outline. The apex is often angular at the corners of the leaf-blade and at the sinus, at other times it is rounded. The sinus may be shallow or moderately deep. The leaflets are much wider than in the following species, and the width is usually greatest in the upper part, although this feature is far from constant.

This species is very common at a number of localities in the New Jersey Raritan and also on Marthas Vineyard, Long Island and Staten Island. It is equally common in the Tuscaloosa formation of Alabama. None of the American specimens, abundant as they are, shows definitely its trifoliate nature, but this is indicated by the relative position of the leaflets in some of the specimens figured by Hollick (loc. cit).

These leaves were segregated from *Liriodendron* by Newberry, on the basis of their simple nature, emarginate apex, crowded and fine venation and relatively small size, although their describer says that they are evidently related to *Liriodendron.* Since 1896, much new material has been collected, especially from Long Island. Holm,[1] as long ago as 1890, suggested that these leaves were not related to *Liriodendron,* but were comparable to those of a number of leguminous genera. Somewhat similar leaves were described from Bohemia as *Myrsinophyllum varians,* by Velenovsky,[2] and more closely allied forms as *Bignonia pulcherrima,* by Bayer,[3] the latter sufficiently well preserved to show their trifoliate nature.

Ward[4] refers a species described by Saporta as a *Chondrophyton,* from the Cenomanian of Portugal to *Liriodendropsis,* to which it is obviously not related, as the writer pointed out some years ago.[5] Recently, Hollick[6] has given a resumé of the genus, together with descriptions of new species and a large number of illustrations. The probabilities are all in favor of their reference to the Leguminosæ, to which family they are referred in the present contribution.

Occurrence.—Woodbridge, Milltown, Hylton Pits.

Collections.—N. Y. Botanical Garden.

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[1] Holm, Proc. U. S.Nat. Mus., 13: 15–35, 1890; Bot. Gaz. 20: 312–316, 1895.

[2] Velen., Kvetena ceského cenomanu, 25, pl. 4, f. 8, 9; pl. 5, f. 12; pl. 6, f. 10, 11, 1889.

[3] Studien Gebiete Böhm. Kreidef. (Perucer Schichten) 1900 (1901), p. 156, f. 126a, b.

[4] Ward, 16th Ann. Rept. U. S. Geol. Survey, pt. 1 : 540, pl. 107, f. 6–8, 1896.

[5] Berry, Bull Torrey Club, vol. 31 : 77, 1904.

[6] Hollick, Mon. U. S. Geol. Survey, vol. L: 69–73, 1907.

Liriodendropsis angustifolia Newb.

Liriodendron simplex Newb., Bull. Torrey Club, vol. 14:6, *pl. 62, f. 4,* 1887, (pars).
Liriodendropsis angustifolia Newb., Fl. Amboy Clays, 84, *pl. 53, f. 8,* 1896.
Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).
Hollick, U. S. Geol. Survey, Mon. 50:71, *pl. 26, f. 1a, 2–5,* 1907.

Description.—Leaves or leaflets lanceolate to linear-lanceolate in outline, relatively long and narrow, with an emarginate, usually angular apex and a cuneate base. Size variable, from 6 cm. to 9 cm. in length by 1.9 cm. to 3 cm. in greatest breadth, which is never in the upper part of the leaf, the margins usually being straight and almost parallel from the angular apical corners, bowing outward slightly in the lower half of the leaf and curving downward to the rather long petiole. Midrib stout. Secondaries numerous, camptodrome. Tertiaries as in the preceding species.

It may be doubted if this is anything more than a variant of the preceding, but as the remains are so abundant it may represent a closely allied, although specifically distinct type. Hollick has described two additional species in the abundant material of this type contained in the insular Cretaceous flora, i. e., *Liriodendropsis constricta* and *L. spectabilis,* making the latter one extreme of a series of which *L. angustifolia* Newb. is the other. The relations are obviously as pointed out, but it seems questionable, in view of the individual variation even of these segregates, whether it would not have been better to have considered all of these forms as variations of a single species.

The present species is abundant in the Raritan at Woodbridge, and also on Marthas Vineyard and at Glen Cove, Long Island. It is recorded on the identification of Prof. Ward from the Tuscaloosa formation of Alabama, but the writer is unable to verify the latter record.

Occurrence.—Woodbridge, Florida Grove.

Collections.—N. Y. Botanical Garden.

Genus CAESALPINIA Linné.

(Sp. Pl., 1753, p. 380.)

CAESALPINIA COOKIANA Hollick.

Cæsalpinia Cookiana Hollick in Newb., Fl. Amboy Clays, 94, *pl. 42, f. 49, 50,* 1896.

Description.—Leaflets of small size, elliptical in outline, entire, 1 cm. to 1.4 cm. in length by 8 mm. or 9 mm. in breadth across the middle. Apex and base about equally rounded. Texture delicate. Midrib slender. Secondaries few, distant, about 3 subopposite pairs; they branch from the midrib at a wide angle, about 80°, and are, with the exception of the lower pair, straight two-thirds of the distance to the margin, where they turn upward in broadly rounded arches parallel with the margin to join the secondaries next above.

The generic affinity of these fossils is doubtful. They almost certainly represent the leaflets of some compound leguminous leaf, and as nothing is to be gained by an attempt to redefine their generic relations, they are left where they were placed by their describer. The exact locality in the Raritan from which they were collected remains unknown.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

CAESALPINIA RARITANENSIS Berry.

Plate XX, Fig. 3.

Caesalpinia raritanensis Berry, Bull. Torrey Club, vol. 36: 251, 1909.

Description.—Elliptical leaflets about 3 cm. long and 2.2 cm. broad, with markedly emarginate apex; midrib missing; secondaries branching at a wide angle, almost 90° and but slightly curved, anastomosing by broad, evenly rounded loops, about two-thirds of the distance to the margin.

This is possibly only an extraordinary large leaflet of *Caesalpinia Cookiana* Hollick, somewhat more elongated in outline and strictly congeneric with that species. It is, unfortunately, based upon the single imperfect specimen figured.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Genus BAUHINIA Linné.

(Sp. Pl., 1753, p. 374.)

BAUHINIA CRETACEA Newb.

Plate XIX, Fig. 3.

Bauhinia cretacea Newb., Bull. Torrey Club, vol. 13:77, *pl. 56*, 1896; Fl. Amboy Clays, 91, *pl. 43, f. 1–4; pl. 44, f. 1–3*, 1896.

Description.—This handsome species is common at the Woodbridge horizon and is characterized by Professor Newberry as follows: "Leaves large, from 10 cm. to 18 cm. in diameter, general outline circular, deeply two-lobed, sinus reaching below the middle, margin entire, base rounded, lobes oblong or broadly spatulate; nervation strong, radiate or bilateral, midrib slender, from 1 cm. to 4 cm. in length, running to bottom of medial sinus, there forking equally, each slender branch running parallel with the margin of the sinus; lateral nerves strong, usually two, rarely one on each side, springing from a common base, the interior lateral nerve strongest, forking several times and giving off fine branches, which inosculate to form a graceful festoon near the upper margin; the exterior lateral nerves throwing off numerous branches which anastomose in loops near the margin, producing a camptodrome nervation. In those which have but a single lateral nerve the lobes are narrower, and each is covered with the ramifications of the branches, which spring chiefly from the outer side of the single main nerve."

"The form and nervation of these leaves are so precisely those of some of the Bauhinias of the present flora that there can be

no reasonable doubt that we here have the remains of a well-marked species of this genus, which grew near the mouth of the Hudson river in the middle of the Cretaceous age, and was the associate of the magnolias, tulip trees, aralias, etc., which composed the angiosperm forest of eastern North America. In size some of these leaves exceed those of any living Bauhinia, and the outline and nervation indicate that the genus was as perfectly defined and highly specialized in the Cretaceous age as now."

"The living Bauhinias inhabit the tropical and subtropical regions of the Old and New Worlds, India, Mauritius, Surinam, Cuba, Mexico, etc. The genus is closely related to Cercis, and most of the species have a similar habit. In a few the leaves are orbicular or slightly emarginate, but they are generally bilobed, the sinus reaching the middle of the leaf, sometimes extending to the base, as is the case with the only species inhabiting the United States, *B. lunariodes* Gray of Texas and Mexico."

"In most of the East India species the nervation is more crowded than in the fossil leaves before us, each having three and sometimes four lateral nerves, the medial nerve, however, being quite the same. In several oriental species, and all those of the New World, the nervation is simpler and especially like that of the fossil."

A fossil species of Bauhinia from the Tortonian deposits of Oeningen, Baden, was described by Heer as long ago as 1859.[1] Soon afterward Unger described two additional species,[2] both based on pods, from Croatia. Five years later the same author described another species from the Aquitanian of Kumi, Greece.[3] In 1885 Velenovsky described another species from the Cenomanian of Bohemia[4] without, however, recognizing its true relationship. The next year Professor Newberry described the foregoing species, and the following species was added to the Raritan flora when his monograph came out in 1896. In 1908 the writer described a small but striking new species[5] from the

[1] Heer. Fl. Tert. Helv., vol. 3: 109, pl. 134, f. 21, 1859.
[2] Unger, Sylloge, vol. 2: 31, pl. 11, f. 2, 3, 1862.
[3] Unger, Foss, Fl. v. Kumi, 61, pl. 15, f. 36, 1867.
[4] Velenovsky, Fl. Böhm. Kreidef. Th. 4: 12, pl. 6, f. 4, 1885.
[5] Berry, Torreya, vol. 8: 218, f. 3, 1908.

Magothy formation of Maryland and a new and ornate species. as yet undescribed, has been collected from the upper beds of the Tuscaloosa formation in Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

BAUHINIA GIGANTEA Newb.

Bauhinia ? gigantea Newb., Fl. Amboy Clays, 93, *pl. 20, f. 1,* 1896.

Description.—Leaves of immense size for this genus, apparently very similar to the preceding in general appearance, but about 20 cm. in diameter. Lobes deeply cleft, more so than in *Bauhinia cretacea,* and possibly reaching quite to the base. The single nearly complete lobe collected is oblong, unsymmetrical in outline, 20 cm. long by 7 cm. to 8 cm. in width, with an almost straight inner margin. Apex obtuse. The venation is stout, the principal vein starting at the basal inner margin runs almost straight to the apex, dividing the lobe in the ratio of about 1 to 5, it gives off three camptodrome secondaries internally, the lowest of which branches slightly below the middle of the lobe. Externally there are six approximately equidistant and parallel camptodrome secondaries decreasing regularly in size from the base upward.

Only two specimens of this species have been discovered, the more complete one being the single lobe which Prof. Newberry figured. However, there can be no question as to its generic relations. It is very similar to the preceding species, but may be distinguished by its much larger size, more deeply cut lobes, undulate outer margin and by the details of venation, one feature of which is the marked unsymmetrical position of the principal vein.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus DALBERGIA Linné f.

(Suppl., 1781, p. 52.)

DALBERGIA APICULATA Newb.

Dalbergia apiculata Newb., Fl., Amboy Clays, 90, *pl. 42, f. 17–19,* 1896.

Description.—Leaflets obovate in outline, unsymmetrical, 2 cm. to 5 cm. in length by about 1.5 cm. to 2 cm. in greatest breadth, which is in the upper half of the lamina. Apex broadly rounded, tipped with an apiculate point. Base narrowly elongated. Margin entire. Midrib thin, generally curved. Secondaries 6 or 7 pairs, slender, branching from the midrib at an angle of about 45° or slightly more and curving upward, camptodrome.

These leaves undoubtedly belong to some leguminous plant and are of the same general characters as the leaves usually referred to *Dalbergia*. They are frequent at the Woodbridge locality in the lower Raritan beds.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus HYMENAEA Linné.

(Sp. Pl., 1753, p. 1192.)

HYMENAEA DAKOTANA Lesq.

Hymenaea dakotana Lesq., Fl. Dakota Group, 145, *pl. 55, f. 2, 3; pl. 56, f. 1, 2; pl. 62, f. 2,* 1892.
Hollick, Bull. Torrey Club, vol. 21: 56, *pl. 176, f. 4,* 1894; U. S. Geol. Surv., Mon. 50: 83, *pl. 32, f. 5–7,* 1907.
Newb., Fl. Amboy Clays, 90, *pl. 41, f. 14,* 1896.
Berry, Ann. Rept. State Geol. (N. J.) for 1905; 138, 139, *pl. 22, f. 1, 2,* 1906; Bull. Torrey Club, vol. 33: 176, 1906.
Dalbergia Rinkiana Hollick, Trans. N. Y. Acad. Sci., vol. 12: 236, *pl. 6, f. 5,* 1893.

Description.—Leaves compound, generally of 2, rarely 3, elliptical or oblong-lanceolate, unsymmetrical, entire, petiolate leaflets. Leaflets variable in size and outline, usually considerably curved and unsymmetrical, broadest on the outside, ranging from 3 cm. to 8 cm. in length and from 1.2 cm. to 3 cm. in breadth. Apex obtusely pointed to acute, sometimes somewhat recurved. Base cuneate. Midrib narrow, curved. Secondaries slender, often seen with difficulty, 6 to 8 pairs, oblique, parallel, camptodrome, the lower long curved and approximately parallel with the margins.

This species was described by Lesquereux from rather abundant remains preserved in the Dakota sandstones of Kansas, and it has since been recorded from the Raritan or the Magothy formations of Marthas Vineyard, Long Island and New Jersey. The Raritan form is of the smaller, more obtuse type, but is almost an exact counterpart of Lesquereux's *pl. 41, fig. 14*. The Magothy forms are also smaller than most of the Dakota Group forms. Some of these latter are especially interesting in that they show the entire leaves, which are of the following character: The common petiole is stout for a distance of from 5 mm. to 15 mm., where it forks into two stout branches 10 mm. to 15 mm. long, each subtended by a single leaflet. Occasionally there are three leaflets instead of the normal two.

A species of *Hymenaea* was described by Saporta from the Cenomanian of Bohemia[1] which shows considerable resemblance to the American form. Later collections described by Velenovsky[2] contain many leaves which he identifies with Soparta's species, *Hymenaea primigenia,* which he finds is rarely entire and usually with a crenate-dentate margin. Hollick records[3] forms similar to the latter from the Marthas Vineyard Cretaceous, which is probably more recent than the New Jersey Raritan.

The forms from the Atane beds of Greenland which Prof. Heer described as *Dalbergia Rinkiana*[4], are very similar to the

[1] Le Monde des Plantes, p. 199, f. 2, 1879.
[2] Fl. Böhm. Kreidef. theil 3: 9, pl. 5, f. 4; pl. 6, f. 1–4, 1884.
[3] Mon. U. S. Geol. Surv., vol. 50: 84, pl. 32, f. 8, 9, 1907.
[4] Fl. Foss, Arct., vol. VI, ab. 2: 102, pl. 26, f. 1–3, 1882.

larger leaves of *Hymenaea*. They are described as being pinnate, but whether this character is based upon specimens seen or merely upon the fact that the two figured specimens each show two leaves similarly oriented, as if they had once formed part of a pinnate leaf, cannot be determined.

Prof. Newberry failed to record the exact locality for the Raritan plant and it is not contained in any recent collections.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus PHASEOLITES Unger.

(Synop. Pl. Foss., 1845, p. 244.)

PHASEOLITES MANHASSETTENSIS Hollick.

Plate XXII, Fig. 2.

Phaseolites manhassettensis Hollick, Bull. N. Y. Botanical Garden, vol. 3: 414, *pl. 78, f. 1, 2,* 1904; U. S. Geol. Surv., Mon. 50:86, *pl. 32, f. 2, 3,* 1907.

Berry, Bull. Torrey Club, vol. 36: 256, *pl. 18, f. 3,* 1909.

Description.—Leaves ovate-falcate in outline, markedly unsymmetrical, 6 cm. to 7.5 cm. in length by 2.4 cm. to 2.8 cm in greatest breadth, which is below the middle of the leaf. Margins entire. Apex acute. Base cuneate. Petiole short and stout. Midrib stout and curved. Secondaries fine, about 9 pairs, often obsolete, diverging from the midrib at an acute angle.

This species was described from Manhassett Neck, Long Island, a locality which should probably be included within the Raritan formation. The species is scarcely distinguishable from *Phaseolites elegans* described by the same author from Brooklyn, and both are very close to the Dakota Group *Phaseolites formus* Lesq., in fact, it is scarcely conceivable that these extremely limited variations are not all of a single species. However, they should be allowed to stand until more abundant and complete material is at hand for comparison. Another comparison which is suggested is with *Hymenaea dakotana* Lesq.

The Milltown leaf, of which two specimens have been found, is more suggestive of *Phaseolites elegans* in general appearance than it is of the species with which it is identified. This is due to its more slender apical portion. On the other hand, it shows the very full convex base on one side, and the more acutely branching secondaries which are considered specific characters of *Phaseolites manhassettensis*.

Occurrence.—Milltown.

Collections.—U. S. National Museum.

Genus PRUNUS Linné.

(Sp. Pl., 1753, p. 473.)

PRUNUS ? ACUTIFOLIA Newb.

Plate XXII, Fig. 1.

Prunus ? acutifolia Newb., Fl. Amboy Clays, 90, *pl. 14, f. 1,* 1896.

Description.—Leaves ovate in outline, about 4.5 cm. in length by 2.5 cm. in breadth. Apex acute. Base rounded or slightly cuneate. Margins regularly and finely serrate except for a few millimeters at the base. Secondaries indistinct, evidently numerous and parallel, branching from the midrib at an acute angle, about 45°.

This species was based upon a single imperfect specimen from Woodbridge. An additional specimen, lacking the tip, and two other fragments were subsequently collected at South Amboy. A very similar leaf from Gay Head, Marthas Vineyard, is described by Hollick[1] as an *Amelanchier*, and Lesquereux describes leaves and fruit from the Dakota Group as a species of *Prunus* of the Amygdalus section.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

[1] Hollick, Mon. U. S. Geol. Surv., vol. L, 1907, p. 83, pl. 32, f. 1.

Order GERANIALES.

Family RUTACEÆ.

Genus CITROPHYLLUM Berry.

(Bull. Torrey Club, vol. 36, 1909 p. 258.)

CITROPHYLLUM ALIGERA (Lesq.) Berry.

Plate XXI, Figs. 1–8.

Ficus aligera Lesq., Fl. Dakota Group, 84, *pl. 10, f. 3–6,* 1892.
Berry, Rept. State Geologist (N. J.) for 1905, 139: 1906.
Bull. Torrey Club, vol. 33: 172, 1906.
Citrophyllum aligera Berry, Bull. Torrey Club, vol. 36: 258, *pl. 18a, figs. 1–8,* 1909.

Description.—Leaves, small, elliptical to ovate or ovate-lanceolate in outline, coriaceous in texture, varying from 2.5 cm. to 6 cm. in length by 1.8 cm. to 3.2 cm. in breadth. Margins entire, occasionally slightly undulate. Apex rounded or obtusely acuminate. Base rounded, sub-truncate or cuneate. Petiole stout, from .7 cm. to 2 cm. in length, conspicuously alate. The petiolar wings may be oblong-lanceolate in outline or obovate, together they are from 2.5 mm. to 5 mm. in width, averaging about 3.5 mm. Midrib stout. Secondaries fine, more or less obscured by the coriaceous leaf substance, about 9 alternate pairs, branching from the midrib at angles of from 45° to 50°, parallel, camptodrome.

These curious leaves were described by Lesquereux from the Dakota Group as a species of *Ficus* and compared with *Ficus bumelioides* Ettings., and *Ficus mudgei* Lesq., neither of which has alate petioles, while the first has an emarginate apex. Subsequently the same leaves were found in the Magothy formation of New Jersey, and only recently a single small leaf was found in the upper Raritan beds at South Amboy. They exhibit considerable variability in outline, but all have exactly the same aspect and conspicuous alate petiole. They appear to be related to the leaves of the modern genus *Citrus*. The latter have ex-

actly the same texture and venation, the same variability in outline and marginal undulations, the same stout midrib and conspicuously alate petioles. In examining a suite of specimens of the latter and comparing them with the fossils the conclusion seems to be irresistible that they are related, and the writer has consequently referred the fossils to a new genus which emphasizes this relationship to the modern genus. All of the fossil specimens which are at all complete are figured on Plate xxi, and two modern leaves are introduced for comparison. Possible arguments against the present view may be based on the theory that the modern alate petioles are derived from ancestors with compound leaves; in fact, some modern species still have trifoliate leaves, and if this were true of the fossils as well, it would require considerable rapidity of evolution in this genus previous to the mid-Cretaceous. The modern leaves absciss from the top of the petiole, and would be unlikely to occur as fossils with the petiole attached, neither can any indication of such an abscission line be made out in the fossils. This is the most difficult argument to combat. However, modern leaves are sometimes shed in their entirety, and we are justified in predicating the occasional fall of leaves before maturity when the abscission layer of cells had not yet become weakened. The agency might be violent winds, the passage of large animals like some of the Cretaceous dinosaurs, or weakened conditions due to insect or fungous diseases.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Order SAPINDALES.

Family ILICACEÆ.

Genus ILEX Linné.

(Sp. Pl., 1753, p. 125.)

ILEX ? ELONGATA Newb.

Ilex ? elongata Newb., Fl. Amboy Clays, 98, *pl. 18, f. 1, 5,* 1896.

Description.—Leaves of relative large size for this genus, lanceolate in outline, 10 cm. to 13 cm. in length, by 3 cm. in greatest breadth. Apex and base acute. Margin with remote spiny teeth. Midrib, stout. Secondaries thin, apparently craspedodrome, branching from the midrib at an acute angle in the middle of the leaf, but at a much wider angle toward the apex.

This species is based upon the two incomplete specimens figured by Prof. Newberry (loc. cit.), which are the only specimens that have ever been collected. Consequently, the diagnosis is somewhat incomplete, the generic relationship is uncertain and the reference to *Ilex* can only be provisional.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

ILEX AMBOYENSIS Berry.

Ilex ? ovata Newb., Fl. Amboy Clays, 98, *pl. 18, f. 2,* 1896 (non Gœpp. 1852).
Ilex amboyensis Berry, Bull. Torrey Club, vol. 36:259, 1909.

Description.—Leaves small, broadly lanceolate in outline, about 4 cm. in length, by 2 cm. in breadth. Apex obtuse. Base narrowed and apparently acute. Margin beset with small and large subacute teeth. Midrib mediumly stout and curved. Only a few secondaries are visible, these branch from the midrib at

angles of about 45° and with but slight curving run directly to the marginal teeth.

This species was based on the single specimen figured by Prof. Newberry (loc. cit.), and no additional specimens have come to light. Although associated with the preceding, it is abundantly distinct. Like the former, however, its botanical affinity is uncertain. Prof. Newberry's name was a preoccupied one and the present name is given in allusion to the general locality.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Family CELASTRACEÆ.

Genus CELASTRUS Linné.

(Sp. Pl., 1753, p. 196.)

CELASTRUS ARCTICA Heer.

Plate XXV, Figs 1–5.

Celastrus arctica Heer, Fl. Foss. Arct., vol. 7:40, *pl. 61, f. 5d, e,* 1883.

Newb., Fl. Amboy Clays, 98, *pl. 13, f. 8–18,* 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 60, *pl. 4, f. 8,* 1898; Bull. N. Y. Bot. Garden, vol. 3: 408, *pl. 70, f. 12, 13,* 1904; U. S. Geol. Surv. Mon., 50: 88, *pl. 33, f. 9–11,* 1907.

Description.—"C. foliis parvulis, lineari-lanceolatis, apice longe attenuatis, basi angustatis, denticulatis, nervis secundariis angulo acuto egredientibus." Heer, 1883.

Leaves elongated and narrow, linear-lanceolate in outline, with an equally acuminate apex and base and a short, stout petiole, ranging from 4 cm. to 13 cm. in length, by from 0.5 cm. to 1.5 cm. in breadth. Midrib stout. Secondaries numerous, parallel, nearly straight, branching from the midrib at acute angles ranging from 12° to 37°, inosculating near the margin, short branches from this marginal hem entering the teeth. Margin regularly

and somewhat remotely dentate, with shallow, rounded sinuses between the teeth, the cuneate base entire margined.

This species, which is excessively abundant in the upper Raritan beds at South Amboy, but which has not been found elsewhere in the New Jersey Raritan, was described originally from the Patoot beds of Greenland, which are usually correlated with the Senonian of Europe. The Greenland material was limited and the specimens were small in size compared with the usual Raritan forms. There is no question of their identity, however. Professor Heer compared them with *Celastrus Ettingshauseni*, of the European Tertiary, which resembles a number of modern species of *Celastrus* of the East Indian region. The present fossils exhibit considerable resemblance to the leaflets of the palmately compound Dewalqueas of the European Upper Cretaceous and Lower Eocene, but no evidence of a similar habit is indicated among the large number of specimens collected from South Amboy.

This species is recorded by Hollick from Block Island and Long Island, and is also present in the Kreischerville beds of Staten Island.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Genus CELASTROPHYLLUM Goeppert.

(Tertiarfl. Insel Java, 1854, p. 52.)

CELASTROPHYLLUM MINUS Hollick.

Plate XXII, Fig. 3.

Celastrophyllum minus Hollick in Newb., Fl. Amboy Clays, 105, *pl. 42, f. 51, 52,* 1896.

Description.—Leaves small, 12 mm. to 13 mm. in length by about 8 mm. in greatest breadth, broadly spatulate in outline. Margin entire or somewhat irregularly and feebly crenate in the upper half of the leaf. Apex broadly rounded. Base narrow,

cuneate, decurrent on the relatively long petiole. Venation obsolete.

This small species was based on a limited amount of material in Prof. Newberry's collection, which lacked information as to the exact locality. It has not since been collected and is to be regarded as obscure in its affinities, although it resembles the forms which Newbeery called *Celastrophyllum robustum* and *C. spatulatum*, and may possibly represent small leaves of either of these species.

Occurrence.—Milltown.

Collections.—N. Y. Botanical Garden.

Celastrophyllum Newberryanum Hollick.

Plate XXII, Figs. 5–7.

Celastrophyllum Newberryanum Hollick in Newb., Fl. Amboy Clays, 101, *pl. 49, f. 1–27*, 1896; Trans. N. Y. Acad. Sci., vol. 16: 133, *pl. 14, f. 1*, 1897.

Knowlton in White & Schuchert, Bull. Geol. Soc. Amer., vol. 9: 353, 1898.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 85, 1903; Bull. Torrey Club, vol. 31: 78, 1904.

Description.—Leaves of medium size, 2.5 cm. to 6 cm. in length by 1 cm. to 2.5 cm. in breadth, ranging in outline from narrowly to broadly ovate or obovate. Apex somewhat rounded, although it may be acute or apiculate in the narrower forms. Base somewhat cuneate and slightly decurrent. Margin entire in the basal half or third of the leaf, sometimes so throughout, elsewhere with mostly small, closely set, appressed denticles. Midrib mediumly stout. Secondaries 5 or 6 pairs, branching from the midrib at angles of about 45°, curved, camptodrome.

In size, outline and venation this species, which is exceedingly abundant, is very close to various modern members of the family Celastraceae, and may be compared with our existing *Celastrus scadens* Linné, which it closely resembles.

It is probably present in the Atane beds of Greenland in some of the leaves which Heer includes under his *Celastrophyllum crenatum*, and it has been reported by Hollick from the Magothy formation at Cliffwood bluff, where it is apparently rare. It would seem as if such an abundant element in the late Raritan would be present in allied floras to the southward, although as yet its presence has not been detected. A new species which occurs in the Magothy formation at Grove Point, Maryland, approaches *Celastrophyllum Newberryanum* and is probably a direct descendant from it.

Forms from the Bohemian Cretaceous, which are practically identical with the smaller and more pointed leaves of this species, are referred by Velenovsky[1] to the genus *Phillyrea* of the Oleaceæ and compared with the living *Phillyrea latifolia* Linné of southern Europe.

Occurrence.—Sayreville, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM UNDULATUM Newb.

Celastrophyllum undulatum Newb., Fl. Amboy Clays, 102, *pl. 38, f. 1–3*, 1896.
Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Description.—Leaves of large size, 10 cm. to 15 cm. in length by 4 cm. to 8 cm. in breadth, ovate oblong or ovate in outline, with an obtuse or bluntly pointed apex and somewhat narrowed base. Margin strongly undulate or broadly and coarsely crenate, somewhat variable in the character of its teeth. Midrib stout. Secondaries numerous, a dozen or more sub-opposite pairs, which branch from the midrib at a wide angle and fork near the margins to form festoons which coincide approximately with the marginal teeth.

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[1] *Phillyrea Englehardti* Velen., Fl. Böhm. Kreidef., Theil. IV., 1885, p. 7, *pl. iv., figs. 2–5.*

This very large species resembles the larger leaves which are referred to *Celastrophyllum crenatum* Heer, but is much larger and more elongate in outline. Its size has apparently rendered perfect specimens rare and the recovered remains are usually fragmentary. Velenovsky hints at its identity with the leaves named by him *Myrica Zenkeri* from the Bohemian Cretaceous, although this resemblance is obviously slight, the present species more nearly resembling the Bohemian leaves which this author identifies as a species of *Ternstroemia*.

It has been reported from the Tuscaloosa formation of Alabama, and the writer has obtained material even larger than the largest New Jersey specimens from the Bladen formation of North Carolina.

Occurrence.—Sayreville, Woodbridge.

Collections.—N. Y. Botanical Garden.

CELASTROPHYLLUM DECURRENS Lesq.

Plate XXII, Fig. 8.

Celastrophyllum decurrens Lesq., Fl. Dakota Group, 172, *pl. 36, f. 1*, 1892.

Celastrophyllum angustifolium Newb., Fl. Amboy Clays, 100, *pl. 14, f. 8–17*, 1896.

Description.—Leaves of variable size, 5 cm. to 15 cm. in length by 1.5 cm. to 4 cm. in breadth, lanceolate, tapering almost equally in both directions. Apex usually acuminate, rarely subacute. Base narrowed and decurrent. Margins entire toward the base, above serrulate, or finely crenate-dentate. Midrib stout. Secondaries fine and very numerous, usually about 2 mm. apart, parallel, diverging from the midrib at an angle of 40° to 45°, finally branching and forming an intricate network along the margin, the ultimate branches running directly to the margin.

The single specimen from the Dakota Group of Kansas, upon which Lesquereux founded this species is not specifically distinct from the more abundant leaves from the Raritan, which Newberry called *Celastrophyllum angustifolium*, the latter serving simply to show the limits of variation of the former. Les-

quereux compared his leaf to *Celastrophyllum lanceolatum* Ettings. and Newberry in discussing Velenovsky's treatment of *Myrica Zenkeri,* is quite positive that the present species is a *Celastrophyllum.* The evidence for this is by no means as conclusive as Newberry thought it was, and it will probably be demonstrated in the future that the present species is a *Myrica* and not a *Celastrophyllum,* another alternative being to regard it as a species of *Dryandroides,* the genus to which Ettingshausen originally referred *Myrica Zenkeri.*

This species apparently ranges throughout the Raritan, the writer being able to add Milltown and South Amboy to the recorded localities.

Occurrence.—Woodbridge, South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM CRETACEUM Lesq.

Celastrophyllum cretaceum Lesq., Fl. Dakota Group, 173, *pl. 38, f. 12–14,* 1892.

Newb., Fl. Amboy Clays, 100, *pl. 42, f. 13,* 1896.

Description.—Leaves small, 2 cm. to 4 cm. in length by 0.9 cm. to 1.2 cm. in breadth, elliptical or oblong in outline. Apex obtusely rounded. Base narrowed, giving some of the leaves an almost spatulate outline. Texture thick, subcoriaceous. Margin entire throughout. Midrib comparatively stout. Secondaries slender, branching from the midrib at an angle of 30° to 40°, slightly curved, distant, parallel, often obsolete, camptodrome.

These leaves, which occur in some abundance in the Dakota Group of Kansas and reappearing in the Raritan, are by no means satisfactorily correlated with the genus *Celastrophyllum* and suggest some Ericaceous genus.

This species is not contained in any recent collections from New Jersey, and Newberry again failed to record the localities from which his material was obtained.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Celastrophyllum crenatum Heer.

Plate XXII, Fig. 9; Plate XXIII, Fig. 2.

Celastrophyllum crenatum Heer, Fl. Foss. Arct., vol. 7: 41, *pl. 62, f. 21*, 1883.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newberry, Fl. Amboy Clays, 99, *pl. 48, f. 1–19*, 1896.
Berry, Bull. Torrey Club, vol. 34: 197, *pl. 13, f. 5*, 1907.

Description.—"C. foliis parvulis, membranaceis, ellipticis, crenatis, nervis secundariis numerosis, valde camptodromis, reticulato venosis." Heer, 1883.

Leaves very variable in size, 2 cm. to 8 cm. in length by 1 cm. to 5 cm. in breadth, ovate or elliptical in outline, broadly rounded above, narrowed and inequilateral below. Margins entire below, coarsely toothed above with somewhat variable rounded, crenate or crenate-dentate teeth. Occasional specimens are entire throughout and some have a markedly inequilateral base. Midrib mediumly stout. Secondaries numerous, 9 to 10 pairs, subopposite, branching from the midrib at an angle somewhat in excess of 45°, slightly curved upward and parallel, branching near the margin to form festoons from which branches enter the marginal teeth.

This species was described by Heer from the Patoot beds of Greenland, and unfortunately only a single small leaf was figured. The Raritan leaves, which are abundant, grade into much larger forms, which are also present in the Bladen formation of North Carolina and the Tuscaloosa formation of Alabama.

Occurrence.—Sayreville, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Celastrophyllum spatulatum Newb.

Plate XXII, Fig. 4.

Celastrophyllum spatulatum Newb., Fl. Amboy Clays, 103, *pl. 42, f. 43–45*, 1896.
Celastrophyllum robustum, Newb., Ibid., *f. 41, 42*.

Description.—Leaves small, 3 cm. to 4 cm. in length by 1.4 cm. to 3 cm. in breadth, ovate to broadly spatulate in outline. Apex rounded more or less broadly. Base narrowed and decurrent. Margins entire below, dentate above, the teeth usually confined to the apical third of the leaf. Midrib usually somewhat curved, giving the leaves an unsymmetrical appearance. Secondaries 6 to 8 pairs, branching from the midrib at an acute angle, curving slightly upward, camptodrome.

The more narrow forms were separated from the broader forms by Prof. Newberry, both being given specific rank, although it seems obvious that they are the variable extremes of a single species, and that not an especially variable one. They approach rather closely to *Celastrophyllum Brittonianum* Hollick, but are readily distinguishable by their less symmetrical shape and narrower base, their coarser and less numerous teeth, and their usually more numerous, more ascending, and straighter secondaries.

No localities for this species are given in Prof. Newberry's Monograph. Later collections show it to be abundant in the upper Raritan at South Amboy.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM GRANDIFOLIUM Newb.

Plate XXIII, Fig. 1.

Celastrophyllum grandifolium Newb., Fl. Amboy Clays, 104, *pl. 19, f. 8; pl. 21, f. 1–4,* 1896.

? Hollick, Mon. U. S. Geol. Surv., vol. 50: 88, *pl. 33, f. 8,* 1907.

Description.—Leaves large, 12 cm. to 25 cm. in length, by 4 cm. to 7 cm. in breadth, ovate-lanceolate in outline. Apex rounded or subacute. Base varying from rounded to cuneate. Margins entire below, above somewhat irregularly undulate or closely serrate, or with coarse, rounded teeth. Petiole long (up to 4.5 cm.), very stout. Midrib stout. Secondaries numerous

and slender for such large leaves, 12 to 15 pairs, branching from the midrib at angles of 45° or slightly more, somewhat flexuous and iregular in their course, camptodrome. Tertiaries generally transverse, forming a coarsely quadrangular areolation.

This species is quite variable, not only in size, but especially in marginal characters, which show every gradation from nearly entire forms to closely serrate forms; this is, however, a character which is more or less variable in all of the Raritan species of this genus. This is a very distinct species, however, its nearest ally apparently being *Celastrophyllum lanceolatum*, described by Ettingshausen from the Cretaceous of Saxony,[1] and which Heer apparently recognized in his Greenland material.[2]

Numerous specimens from New Jersey are in Newberry's collection, but none have the locality labels preserved. Two specimens were obtained in recent collections from Milltown.

Occurrence.—Milltown.

Collections.—N. Y. Botanical Garden.

Celastrophyllum Brittonianum Hollick.

Celastrophyllum Brittonianum Hollick in Newb., Fl. Amboy Clays, 105, *pl. 42, f. 37, 38, 46, 47,* 1896.

Ward, 15th Ann. Rept. U. S. Geol. Surv., 349, 358, 377, 378, 379, 1895 (nomen nudum).

Mon. U. S. Geol. Surv. vol. 48: 493, *pl. 107, f. 7,* 1906.

Description.—Leaves small, 4 cm. to 5 cm. in length, by 1.2 cm. to 1.5 cm. in breadth, lanceolate, or in some specimens somewhat spatulate in outline. Apex subacute. Base somewhat decurrent and straight sided. Margins entire below, denticulate above. Midrib stout. Secondaries numerous, somewhat irregular, of fine calibre but prominent, camptodrome.

This species is clearly distinct from *Celastrophyllum spatulatum* Newb., although it stands nearer the latter than to any

[1] Ettingshausen, Kreidfl. von Niederschoena, 1867, p. 260, pl. iii, fig. 9.

[2] Heer, Fl. Foss. Arct., vol. VII, 1883, p. 40, *pl. lxiv, fig. 9a; pl. lxv, figs. 7, 8.*

other known form. It seems to be a somewhat older type, since it has been recognized in the considerably older deposits of the Patapsco formation in Virginia. It would be interesting to know from what horizon or horizons in the Raritan it had been collected, but Prof. Newberry failed to indicate the locality in connection with any of his several specimens, and it has not been collected since his day.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Family ACERACEÆ.

Genus ACER Linné.

(Sp. Pl., 1753. p. 1055.)

Acer amboyense Newb.

Acer amboyense Newb., Fl. Amboy Clays, 106, *pl. 46, f. 5–8,* 1896.

Acer sp., Hollick, Mon. U. S. Geol. Surv., vol. 50:89, *pl. 33, f. 12, 13,* 1907.

Description.—Leaves unknown. Species based on fruits (samara) which resemble greatly those of the modern red maple of this latitude. They are somewhat variable in appearance, in the size of the carpel and in the outline of the wing, but these are interpreted as examples of variability such as may readily be seen in examining a series of fruits of the modern species.

The carpel proper varies in diameter from 3 mm. by 2 mm., to 7 mm. by 3 mm., the latter probably being nearer the normal form. The wing varies in length from 1 cm. to 1.7 cm., probably averaging about 1.5 cm. and in breadth from 5 mm. to 9 mm. The lower margin is thickened and curved (straight in one specimen) with the characteristic parallel, curving, occasionally forked veins.

Although these remains are fairly common and seem clearly allied to *Acer,* no leaves of this genus have been discovered in

the Raritan and a single, poorly defined leaf is referred to *Acer* from the insular Cretaceous flora. This absence of foliar remains suggests that these remains are more properly comparable with the winged seeds of conifers like those of *Pinus*, leaves of which are common in the Raritan formation. Judged by the modern representatives they are much more like *Acer* than *Pinus* or other conifers, and they are therefore retained in the genus where they were placed by Prof. Newberry.

In addition to specimens from Woodbridge and South Amboy, undoubtedly similar specimens are recorded from Marthas Vineyard.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Order RHAMNALES.

Family RHAMNACEÆ.

Genus RHAMNITES Forbes.

(Quart. Jour. Geol. Soc. Lond., vol. VII, 1851, p. 103.)

RHAMNITES MINOR Hollick.

Rhamnites minor Hollick, in Newb., Fl. Amboy Clays, 106, *pl. 42, f. 36,* 1896.

Description.—Leaves small, ovate in outline, 1.9 cm. or 2 cm. in length and 1.1 cm. or 1.2 cm. in greatest breadth, which is at the middle of the leaf. Apex rounded. Base cuneate, slightly decurrent to the extremely short and stout petiole. Venation fine. Secondaries, few, 4 or 5 pairs, subopposite; the lower diverge at an acute angle and run parallel with the margin; the upper are much shorter and more oblique; all camptodrome.

This species is based on the single specimen figured in Prof. Newberry's monograph (loc. cit) and no additional examples have come to light. In general appearance and venation it is con-

generic and closely resembles *Rhamnites apiculatus* Lesq..[1] but is of smaller size and has a less acute tip and a shorter petiole The original locality in the Raritan from which the specimen was collected is not recorded.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Family VITACEÆ.

Genus HEDERA Linné.

(Sp. Pl., 1753, p. 202.)

HEDERA OBLIQUA, Newb.

Hedera obliqua Newb., Fl. Amboy Clays, 113, *pl. 37, f. 8; pl. 38, f. 5,* 1896.

Description.—Leaves large, obliquely elliptical in outline, markedly unsymmetrical, 9 cm. to 15 cm. in length by 8 cm. to 11 cm. in width. Margins somewhat undulate, especially distad. Petiole stout, 2.3 cm. or more in length. Apex broadly rounded or emarginate. Base rounded or truncate. Primaries 5 or more, palmate, diverging at acute angles from the top of the thickened petiole, the midrib the stoutest; the balance fork or soon curve to join branches from the midrib, forming a somewhat irregular and open network of camptodrome arches.

This species may be nothing more than a variant of *Hedera primordialis* Saporta, which it greatly resembles, since it is much less abundant. It is, however, generally larger in size, strikingly unsymmetrical and lacks the cordate base of that species. It is confined to the Woodbridge locality.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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[1] Lesq., Fl. Dakota Group, 171, pl. 37, f. 8–13, 1892.

HEDERA PRIMORDIALIS Saporta.

Hedera primordialis Sap., Le Monde des Pl., 200, *f. 29, 1, 2,* 1879.
Velen., Fl. Böhm Kreidef. Theil 1: 19 *pl. 8, f. 7; pl. 9, f. 4, 5; pl. 10, f. 3, 4,* 1882.
Heer, Fl. Foss. Arct., vol. 6, ab. 2: 82, *pl. 15, f. 9, 10; pl. 24, f. 6, 7a; pl. 28, f. 13, 14,* 1882.
Newb., Fl. Amboy Clays, 113, *pl. 19, f. 1, 9; pl. 37, f. 1–7,* 1896.
Berry, Bull. Torrey Club, vol. 34: 201, *pl. 16,* 1907.

Description.—Leaves elliptical, reniform, or cordate in outline, very variable in size and shape. Length 3 cm. to 12 cm., breadth 3.2 cm. to 12 cm., usually broader than long. Apex rounded or obtusely pointed, sometimes slightly emarginate. Margin somewhat irregular but entire. Base varying from truncate to deeply cordate. Petiole long and stout, usually not preserved. Venation palmate from top of the petiole. Primaries varying in number from 3 to 7, usually 5 to 7, of which the midrib is the stoutest, especially in the smaller leaves. The lowest pair of primaries, which are approximately parallel with the basal margins of the leaf, are smaller in size than the others, and should, perhaps, be regarded as secondaries. If this is done the primaries are normally 5 in number, curved and camptodrome.

This species was figured by Saporta in 1879 from the Cenomanian of Bohemia and described three years later by Velenovsky from the same horizon. Heer identifies rather fragmentary remains from the Atane beds of Greenland with this species, which is also abundant in the Woodbridge Raritan and in the Bladen formation of North Carolina. It varies greatly in size and appearance, some of the smaller specimens from abroad suggesting the genus *Cercis,* while the smaller Raritan leaves suggest somewhat the genus *Ficus.* Of these variable specimens we are disposed to consider as typical Velenovsky's *Pl. X, fig. 4,* and Saporta's *fig. 2,* as well as various Woodbridge specimens, which are, however, mostly incomplete.

This is a remarkably widespread species and better characterized where it does occur than is usually the case in such cosmo-

politan types. It is an important horizon marker and by itself is almost sufficient to fix the age of the Raritan as Cenomanian. Although the modern representation of this genus is reduced to two species in Europe and northern Africa and a third in Japan, it seems to have been a more or less prominent type in the Cretaceous and Tertiary floras of the globe. In addition to the present species, which has the wide range previously mentioned, eight or ten additional Cretaceous species, mostly American, are known. The Eocene, both of America and Europe, furnishes six or eight species; the Oligocene, of Europe and the Arctic regions, one or two species, and the Miocene and Pliocene two or three additional. The modern Old World *Hedera Helix* Linné is recorded from the Pleistocene (Interglacial) of England, Italy and the Paris basin, and one of the Upper Miocene species appears also to have survided into the Italian Pleistocene. While so abundant an element in our Cretaceous floras, it is not a native plant in the existing flora of North America.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CISSITES Heer.

(Phyll. Crét. Nebr., 1866, p. 19.)

Cissites formosus Heer.

Cissites formosus Heer, Fl. Foss. Arct., vol. 6, ab. 2:85, *pl. 21, f. 5–8*, 1882.

Lesq., Fl. Dakota Group, 161, *pl. 21, f. 5*, 1892

? Hollick, Bull. Torrey Club, vol. 21: 57, *pl. 174, f. 6*, 1894; U. S. Geol. Surv. Mon. 50: 94, *pl. 37, f. 7*, 1907.

Newb., Fl. Amboy Clays, 107, *pl. 47, f. 1–8*, 1896.

Description.—"C. foliis palmatis, profunde trilobatis, lobo medio basi contracto, trilobato, lobis obtusis." Heer, 1882.

The foregoing description was based upon very fragmentary material from the Atane beds of Greenland, from which, nevertheless, Prof. Heer reconstructed the supposed outline of the perfect leaf. Judging by the specimens referred to this species

by Lesquereux and Newberry, it was an exceedingly variable form. In plan it was trilobate, but the subsidiary lobes developed upon both the median and the lateral lobes obscures this trilobate character and suggests *Cissites parvifolius* Berry[1] of the Albian of America and Europe, *Cissites dentato-lobatus* Lesq., of the Dakota Group or *Cissus vitifolia* Velen. of the Cenomanian of Bohemia.

The primaries are stout and 3 in number; they may diverge from the top of the stout petiole or be supra-basilar; very often the branches of the laterals approach so near the base that the leaves have the appearance of being palmately 5-veined.

This species is common but fragmentary in the Raritan beds; it ranges in size from 7 cm. to 10 cm. in length and from 6 cm. to 12 cm. between the tips of the main lateral lobes. The sinuses are all rounded, and the main ones may be deep or shallow. The fragment from Long Island referred to this species by Hollick is, as that writer remarks, exceedingly unsatisfactory and doubtful.

The genus *Cissites* was instituted by Heer in 1866 for the species *Cissites insignis* from the Dakota Group of Nebraska, which presented various points of affinity with the genus *Cissus* of Linné. It is a largely developed type in the upper half of the Cretaceous period, but is replaced after the Eocene by forms which are definitely referable to the modern allied genera such as *Cissus*, *Vitis*, etc.

Occurrence.—Sayreville, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CISSITES CRISPUS Velen. ?

Cissites crispus Velen., Fl. Böhm. Kreidef., Th. 4: 12, *pl. 4, f. 6,* 1885.

? Newb., Fl. Amboy Clays, 108, *pl. 42, f. 20–23,* 1896.

? Berry, Bull. Torrey Club, vol. 33: 177, 1906.

Description.—"Das abgebildete Fragment gehört einem kleinen Blättchen von rundlicher Form und handförmiger Nerva-

[1] Founded on the species of *Vitiphyllum* of Fontaine and *Cissites obtusilobus* Saporta.

tion. Es ist am Rande geschnitten gezähnt. Die Haupt-und Secondärnerven sind scharf hervortretend Die Blattfläche zwischen den stärkeren Nerven ist faltig gewölbt. Velenovsky, 1885.

This species is characterized by Velenovsky as quoted above. The American remains of small deeply toothed or incised leaves, while they resemble the Bohemian form and are probably related to it, are doubtfully identical with it. This is especially true of the Magothy leaves contained in carbonate of iron nodules, which the writer has identified as this species from New Jersey and Delaware; both this and the Raritan determinations are, therefore, questioned in the foregoing synonomy.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Order MALVALES.

Family STERCULIACEÆ.

Genus PTEROSPERMITES Heer.

(Fl. Tert. Helv. vol. III, 1859, p. 37.)

PTEROSPERMITES OBOVATUS (Newb.) Berry.

Protophyllum obovatum Newb., Fl. Amboy Clays, 128, *pl. 38, f. 4,* 1896.

Pterospermites obovatus Berry, Bull. Torrey Club, vol. 36: 259, 1909.

Description.—Leaf elliptical in outline, about 12 cm. in length by 7.5 cm. in greatest breadth, which is near the middle. Margins entire. Midrib stout. Secondaries about 10 pairs, sub-opposite to alternate, comparatively slender and somewhat flexuous, camptodrome. Apex apparently rounded. Base contracted and then prominently auriculate, the three or four secondaries involved radiating from the base of the midrib.

This species is based upon a single specimen from Woodridge, which Professor Newberry suggested might be related to the modern species of *Coccoloba.*

Very little can be said in favor of the reference of this leaf to Lesquereux's genus *Protophyllum*, all of the species of which differ from it in outline and marginal characters. Professor Newberry places great reliance upon the character of the base, but in the Raritan specimen this is decidedly auriculate and not subpeltate and the veins in this part of the leaf are radiate and not more or less parallel. Finally, the venation is distinctly camptodrome and not craspedodrome, as it is in Lesquereux's definition of the genus and in all other species which have subsequently been referred to it. For these reasons it is here placed in the genus *Pterospermites*, which seems to be a more natural arrangement. It may be compared with *Pterospermites auriculatus* Heer[1] of the Atane beds of Greenland, which, while somewhat different in outline, is a leaf of the same general facies and is undoubtedly congeneric.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order PARIETALES.

Family PASSIFLORACEÆ Linné.

Genus PASSIFLORA Linné.

(Sp. Pl., 1753, p. 955.)

PASSIFLORA ANTIQUA Newb.

Plate XXIII, Fig. 5.

Passiflora antiqua Newb., Fl. Amboy Clays, 109, *pl. 23, f. 7,* 1896.

Description.—Leaves of medium size, narrowly bilobate, the lobes widely diverging at an angle of about 45°, rounded apically. Sinus open, rounded. Base broadly cuneate. Petiole stout. Margins entire. Primaries 3 palmate from top of

[1] Heer, Fl. Foss. Arct. vol. 6, Ab. 2:95, *pl. 27, f. 4,* 1882.

the petiole, diverging at acute angles, the midrib running straight to the base of the sinus, the laterals but slightly curved in passing to the tips of the lobes. Secondaries remote, fine, camptodrome.

Passiflora is entirely a warm temperate or tropical type, and while it is found in both Asia and Australia it is primarily American and makes its greatest display in the tropics of Central and South America. Perhaps 250 species in all have been described.

Fossil representatives of this genus are rare. In addition to the present species two characteristic species are described by Friedrich[1] from the much more recent Ligurian deposits of Saxony.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order MYRTALES.

Family MYRTACEÆ.

Genus EUCALYPTUS L'Heritier.

(Sert. Angl., 1788, p. 18.)

EUCALYPTUS GEINITZI (Heer) Heer.

Myrtophyllum Geinitzi Heer, Fl. v. Moletein, *22, pl. 11, f. 3, 4,* 1872; Fl. Foss. Arct., vol. 3, ab. 2: 116. *pl. 32, f. 14–17; pl. 33, f. 6b,* 1874.

Eucalyptus Geinitzi Heer, Fl. Foss. Arct., vol. 6, ab. 2: 93, *pl. 19, f. 1c; pl. 45, f. 4–9; pl. 46, f. 12c, d, 13;* 1882.

Velen., Fl. Böhm. Kreidef. Theil 4: 1, *pl. 1, 2, 3, fig. 1; pl. 4, f. 1, 13,* 1885.

Lesq., Fl. Dakota Group, 138, *pl. 37, f. 20,* 1892.

Newb., Fl. Amboy Clays, 110, *pl. 32, f. 2, 12* (non *f. 15, 16*) 1896.

[1] Friedrich, Beitr. Tertfl. Sachsen, 195, 234, *pl. 25, f. 20; pl. 31, f. 1, 2,* 1883.

Hollick, Ann. N. Y. Acad. Sci., vol. 11:60, *pl. 4, f. 1–3,* 1898; Mon. U. S. Geol. Surv., vol. 50:96, *pl. 35, f. 1–8, 10–12,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3:87, *pl. 53, f. 3,* 1903; Bull. Torrey Club, vol. 31:78, *pl. 4, f. 5,* 1904; Ibid., vol. 33:180, 1906; Ibid., vol. 34:201, *pl. 15, f. 4,* 1907.

Myrtophyllum Warderi Lesq., Fl. Dakota Group, 136, *pl. 53, f. 10,* 1892.

Hollick, Mon. U. S. Geol. Surv., vol. 50:97, *pl. 35, f. 13,* 1907.

Eucalyptus ? angustifolia Newb., (non Desv. 1822) Fl. Amboy Clays, 111, *pl. 32, f. 1, 6, 7,* 1896.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:408, *pl. 70, f. 8, 9,* 1904; Mon. U. S. Geol. Surv., vol. 50:95, *pl. 35, f. 9, 14, 15,* 1907.

Description.—"M. foliis petiolatis, coriaceis, anguste lanceolatis, nervis secundariis sub-angulo acuto egredientibus." Heer, 1872.

A very large number of somewhat variable leaves have been referred to this species since it was described by Heer in 1869 as the type of the genus *Myrtophyllum* and based upon material from the Cenomanian of Moravia. In 1882 the same author definitely referred this form to the genus *Eucalyptus.*

These diverse appearing leaves are, as a rule, of the same general type, and differ merely in size or in the closeness or remoteness of their secondaries, and it seems doubtful if the species as at present understood is composite, as has been claimed by some authors.

In general these leaves are lanceolate in outline (ovate-lanceolate in some Bohemian specimens), broadest near the middle and almost equally tapering in both directions to the acute apex and base. The petioles are very stout, as is the prominently raised midrib. Secondaries numerous, thin, branching from the midrib at acute angles, about 45°, and running with but slight curvature to the marginal hem, which is either almost straight where the secondaries are close-set or more or less bowed where the sec-

ondaries are some little distance apart, as in the Raritan specimens. The larger leaves from New Jersey, which Prof. Newberry referred to this species, are not related to the smaller ones from South Amboy, which appear to be correctly identified.

This species is wide-ranging and has been recorded from a number of Cenomanian localities in Europe and from the Atane beds of Greenland, the Dakota Group of Kansas, the Magothy formation of New Jersey and Delaware, the Bladen formation of North Carolina, from Marthas Vineyard, Block Island, Long Island and Staten Island.

The specimens from South Amboy described by Prof. Newberry as *Eucalyptus angustifolia* are here referred to *Eucalyptus Geinitzi*, to which species the Marthas Vineyard forms certainly belong. The Raritan leaves are segregated by Newberry on the ground of their more attenuated base and apex. This is shown to some extent in his Figure 1, but not in his other two figures, Figure 7 showing a leaf with a rounded base. My experience has been that the observed variation in undoubted leaves of *Eucalyptus Geinitzi* is sufficiently wide to include leaves like those referred to *E. angustifolia.* There is no advantage in maintaining on paper a species based on fragmentary material which it is impossible to differentiate with certainty. The name *E. angustifolia* is antedated by the living species so-called by Desvaux in 1822, and rather than rename the Raritan plant it is referred to the present species.

Under his discussion of *Eucalyptus angustifolia* Prof. Newberry goes into a somewhat lengthy discussion of the objects which Prof. Heer regarded as *Eucalyptus* fruits, and records it as his opinion that they are unrelated to *Eucalyptus* and congeneric with the so-called scales of *Dammara* extensively distributed in mid-Cretaceous deposits. The lapse of time has fully sustained the latter view, and no paleobotanist at the present time would think of supporting the former view.[1]. Not only is this the case, but in one species of *Dammara,* at least, it has been shown by structural specimens that it and presumably all the other species are referable to the Araucarieæ.

[1] Some of the Bohemian remains are not included in this statement.

Occurrence.—Sayreville, Milltown, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

EUCALYPTUS LINEARIFOLIA Berry.

Plate XXVIII, Fig. 8.

Eucalyptus ? nervosa Hollick, Bull. Torrey Club, vol. 21: 56, *pl. 174 f. 10,* 1894; Ann. N. Y. Acad Sci., vol. 11: 61, *pl. 4, f. 5b,* 1898; Mon. U. S. Geol. Surv., vol. 50: 95, *pl. 8, f. 6b; pl. 35, f. 16,* 1907 (non. F. Muell.)
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 112, *pl. 32, f. 3–5, 8,* 1896.
Eucalyptus linearifolia Berry, Bull. Torrey Club, vol. 34: 203, 1907.

Description.—Leaves elongate-linear in outline, 10cm. to 15 cm. in length by 1 cm. or less in width, with entire margins, a narrow cuneate base and a rounded obtuse apex. Midrib stout. Secondaries very numerous, parallel, crowded, 1 mm. to 2 mm. apart; they branch from the midrib at angles of 45° or somewhat less and run in a straight course to the marginal vein, which connects their distal ends in a straight line parallel, and close to, the margin.

This species is very similar to the contemporaneous leaves which have been referred to this genus, and especially to *Eucalyptus Wardiana* Berry[1] described from the overlying Magothy formation; in fact it is quite possible that the leaves from Block Island, Long Island and North Carolina, which have been identified as *Eucalyptus linearifolia*, may really be examples of *Eucalyptus Wardiana.*. The former is also recorded from the Tuscaloosa formation of Alabama.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

[1] Berry, Bull. Torrey Club, 32: 47. 1905.

EUCALYPTUS ? PARVIFOLIA Newb.

Eucalyptus ? parvifolia Newb., Fl., Amboy Clays, 112, *pl. 32, f. 9–10,* 1896.

Description.—Leaves small, lanceolate in outline, 5 cm. to 6 cm. in length by 1.1 cm. to 1.3 cm. in greatest width, which is about midway between the apex and the base, both of which are equally acute. Margins entire. Petiole apparently short. Midrib stout. Secondaries rather fine and remote, camptodrome somewhat angular; there are 9 or 10 subopposite to alternate pairs which branch from the midrib at angles of about 45° or less and inosculate at a considerable distance from the margin, there being no marginal vein present as in the usual leaves of this genus.

While it seems probable that this species is not referable to the genus *Eucalyptus,* nor related to the other leaves from the Raritan formation which are here referred to that genus, the material is so scanty and time-worn that it has seemed wisest to retain it as identified by Prof. Newberry rather than to attempt a re-identification which could not be made with any degree of conclusiveness.

This species has been recorded from the Tuscaloosa formation of Alabama, but like many other specimens from different localities in the Coastal Plain, so identified by Ward, it is not identical with Newberry's leaves, but is referable to *Salix* or *Laurus.*

This restricts the occurrence of the present species to the upper Raritan beds at South Amboy and emphasizes the singular variety and abundance of these supposed *Eucalyptus* leaves at this single horizon in the late Raritan.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

EUCALYPTUS ANGUSTA Velen.

Plate XXVIII, Figs. 1–4.

Eucalyptus angusta Velen., Fl. Böhm. Kreidef., Theil 4: 3, *pl. 3, f. 2–12,* 1885; Kvetena ceskeho cenomanu, 21, *pl. 6, f. 1,* 1889.

Sap., Fl. Foss. Portugal, 207, *pl. 36, f. 12,* 1894.
Berry, Bull. Torrey Club, vol. 36: 260, 1909.

Description.—"Blätter lineal, schmal lineallanzettlich, in der Mitte oder in der unteren Hälfte am breitesten, ganzrandig, vorne in eine sehr lange Spitze vorgezogen und mit einem harten Dorn beendet, Der Primärnerv gerade, ziemlich stark, zur Spitz hin verdünnt. Die Secundärnerven zahlreich, unter spitzen Winkeln entspringend, am Rande durch einen Saumnerv untereinander verbunden. Der Blattstiel gerade, etwa 1 cm. lang, stark." Velenovsky, 1885.

The foregoing is Velenovsky's description of this interesting species which is exceedingly common at a number of localities in the Perucer schichten of Bohemia (Cenomanian), where this author subsequently found fruit-bearing twigs which he described and figured in 1889 and which, it would seem, conclusively establish the botanical relations of these leaves.

Subsequently Saporta (loc. cit.) recorded this species from the Albian beds of Portugal; the latter material is, however, rather incomplete and open to question. Recent collections in our own Coastal Plain show that this species was present in considerable abundance on this side of the Atlantic at the same time that it flourished in Europe. It has been collected from the upper Raritan at South Amboy, where it is common; from the Bladen formation of South Carolina, and from the Upper Cretaceous of Georgia, and may be somewhat more fully characterized as follows:

Leaves alternate or scattered, mostly elongated, linear-lanceolate in outline, often falcate, 4.5 cm. to 15 cm. in length, by 5 mm. to 13.5 mm. in width, with an attenuated acute tip and a narrowly cuneate base declining to the short and stout petiole. Midrib mediumly stout below, becoming attenuated above. Secondaries very numerous, fine, and close-set, about 1 mm. apart, parallel, rather straight; they branch from the midrib at acute angles of about 30° or slightly less and run with but slight curvature to join the well-marked but fine marginal hem which shows in all the American material and in most of

the illustrations of the foreign material. In all respects this is one of the most characteristically *Eucalyptus*-like species of the many which have been so identified, and its totality of characters, combined with the presence of attached fruits in the Bohemian material, which are not unlike some of those of modern forms, renders the identification very satisfactory.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

EUCALYPTUS ? ATTENUATA Newb.

Plate XXVIII, Fig. 6.

Eucalyptus ? attenuata Newb., Fl. Amboy Clays, iii, *pl. 16, f. 2, 3,* (non. *f. 5*) 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Ward, Ann. Rept. U. S. Geol. Surv., 15th: 371, 1895 (nomen nudum).

Berry, Rept. State Geol. (N. J.) for 1905: 138, 1906; Bull. Torrey Club, vol. 33:180, 1906; Ibid., vol. 34; 203, 1907.

Description.—Leaves lanceolate in outline, 9 cm. to 12 cm. in length by 1.5 cm. to 2 cm. in greatest width, which is in the basal half of the leaf. Margin entire, somewhat undulate in some specimens. Apex narrow and produced, acutely pointed. Base cuneate. Petiole stout, 1 cm. to 2 cm. in length. Midrib stout, especially in its lower part. Secondaries numerous, branching from the midrib at an acute angle, reticulate-camptodrome.

This species has little in common with the leaves usually referred to this genus, except its outline, which is also that of a great many unallied genera. It is somewhat suggestive of some of the leaves referred to *Laurophyllum*, in fact many possible relationships could be suggested, all of which possess equal elements of uncertainty, so that it seems wisest to permit Prof. Newberry's identification to stand after pointing out its inconclusive nature.

This species is common in the upper Raritan and has a recorded range of considerable extent in somewhat later formations. It is recorded from the Magothy formation of New Jersey and Maryland, the Bladen formation of North Carolina and the Tuscaloosa formation of Alabama.

Occurrence.—South Amboy, Hylton Pits.

Collections.—N. Y. Botanical Garden.

Order UMBELLALES.

Family CORNACEÆ.

Genus CORNOPHYLLUM Newb.

(Fl. Amboy Clays, 1896, p. 119.)

CORNOPHYLLUM VETUSTUM Newb.

Cornophyllum vetustum Newb., Fl. Amboy Clays, 119, *pl. 19, f. 10,* 1896.

Description.—Leaves elliptical in outline, 7–8 cm. long by about 4 cm. wide, with acute apex and base, the latter slightly decurrent and inequilateral. Margin entire, very slightly undulate. Midrib slender and straight. Secondaries slender, about 7 pairs, opposite or alternate, branching from the midrib at an angle of about 45°, and strongly curved upward, approximately parallel and camptodrome; they increase in length from the apex to the base, the lower ones sweeping upward in strong arches parallel with the margin and all drawn inward toward the apex.

With the exception of the delicate and somewhat flexuous character of the venation, these leaves are strictly comparable with those of *Cornus,* good species of which, very similar to the Raritan leaf, occur in the Dakota Group, in Greenland and in the Magothy formation of Maryland. Doubtless the Raritan species will eventually be referred to that genus, meanwhile the present generic appellation is a sufficient index of its relationship.

This species is rather rare, and as indicated above, serves to ally the Raritan with somewhat younger formations.

Occurrence.—Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Family ARALIACEÆ.

Genus ARALIA Linné.

(Sp. Pl., 1753, p. 273.)

ARALIA NEWBERRYI Berry.

Aralia palmata Newb., Fl. Amboy Clays, 117, *pl. 39, f. 6, 7; pl. 40, f. 3,* 1896 (non Lamarck).
(?) Berry, Bull. N. Y. Botanical Garden, vol. 3:93, *pl. 44,* 1903; Bull. Torrey Club, vol. 31:79, *pl. 4, f. 12,* 1904.
Hollick, U. S. Geol. Surv. Mon. 50:98, *pl. 38, f. 4,* 1907.
Aralia rotundiloba Hollick, Ann. N. Y. Acad. Sci., vol. 11:421, *pl. 38, f. 2,* 1898.
Aarlia sp., Hollick, Ann. Rept. N. Y. State Mus., vol. 55:r50 1903.
Aralia polymorpha Newb., Fl. Amboy Clays, 118, *pl. 39, f. 1–5,* 1896.
Aralia Newberryi Berry, Bull. Torrey Club, vol. 34:201, *pl. 15, f. 1,* 1907.

Description.—Leaves very variable in size and outline, palmately 3 to 5 lobed. Lobes conical, obtusely rounded. Sinuses open, shallow, rounded. Margin entire except basally, where incipient lobations cause undulations. Petiole long and stout. Midrib stout, more or less curved or flexuous. Primaries 3 to 5 from the base, prominent, running to the tips of the lobes. Secondary branches very slender, camptodrome. The middle lobe is usually longest and broadest, and the basal lateral lobes may be reduced to subordinate and but slightly marked divisions of the main lateral lobes.

As can be readily seen, the relative development of the apical or basal lobes and the depths of the intervening sinuses greatly alters the appearance of these leaves. Some are quite symmetrical, while others are very unsymmetrical; some are pre-eminently 3-lobed and sublobate, others are 5-lobed with additional incipient lobes. The variations are almost exactly com-

parable with the similar variations in the leaves of the modern *Sassafras* due to position and age.

There seems to be no basis for maintaining the distinction between *Aralia palmata* and *A. polymorpha* Newb. The species is abundant in the Raritan, and survives in the overlying Magothy formation in a slightly modified form, which may prove eventually to be a distinct species.

The genus *Aralia*, to which this and the several following species are referred, is an important element in the Cretaceous floras of the globe, with many species especially in the Dakota Group and the Bohemian Cenomanian. The large number of species, seven in all, in the Raritan furnishes corroborative evidence of its Cenomanian age.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Aralia quinquepartita Lesq.

Plate XX, Fig. 8; Plate XXIV, Fig. 5.

Aralia quinquepartita Lesq., Ann. Rept. U. S. Geol. and Geog. Surv. Terr., 1871; 302, 1872; Bull. U. S. Geol. Surv. Terr., vol. 1: 394, 1876; Cret. Fl. 90, *pl. 15, f. 6,* 1874; Fl. Dakota Group, 136, 1892.

Newb., Fl. Amboy Clays, 115, *pl. 40, f. 1, 2,* 1896; Mon. U. S. Geol. Surv., vol. XXXV.: 123, *pl. 9, f. 1,* 1898.

Description.—Leaves generally of large size and coriaceous texture, from 5 cm. to 17 cm. in length by from 9 cm. to 17 cm. or possibly more in greatest breadth between the tips of the lateral lobes, petiolate. Palmately 5-lobed. Lobes long, linear or lanceolate in outline, obtusely pointed. Terminal lobe of the same size as the principal lateral lobes from which it is separated by narrow but rounded sinuses extending three-quarters of the distance to the base. The ground plan of the leaf is trilobate, with each of the lateral lobes more or less deeply divided into two almost equal divisions, the basal one of which is more or less subordinate. Primaries stout, 3 in number

from the cuneate base or a slight distance above, running from thence to the tips of the lobes. From 1.5 cm. to 4 cm. above their origin the lateral primaries send off stout, lateral, more or less subordinate branches which run to the tips of the subordinate lobes. These latter may nearly equal the principal lobes as they do in the complete specimen figured by Newberry in 1898, or they may be more or less reduced as they are in the large specimen figured by the same author from Woodbridge, in which the one on the right side is apparently but slightly developed. These lobes are also subordinate in the dainty little leaf of this species figured in the present report from the Hylton Pits. The secondaries are numerous and camptodrome as a rule, although a single one in the last-mentioned specimen runs directly to a prominent serrate point on the lower side of the subordinate lobe, a short distance below its apex.

Although fragmentary remains of this handsome species were discovered during the work of the Hayden Survey in Kansas, and were described by Lesquereux in 1876, the subsequently-collected, more complete material has never been adequately described.

Occurrence.—Woodbridge, Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Aralia groenlandica Heer.

Aralia groenlandica Heer, Fl. Foss. Arct., vol. 6, ab. 2: 84, *pl. 38, f. 3; pl. 39, f. 1; pl. 46, f. 16, 17,* 1882.

Lesq., Fl. Dakota Group, 134, *pl. 54, f. 1–3,* 1892.

Newb., Fl. Amboy Clays, 116, *pl. 28, f. 4,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 94, *pl. 45, f. 4,* 1903.

Hollick, U. S. Geol. Surv. Mon. 50: 98, *pl. 37, f. 3–6,* 1907.

Description.—"A foliis magnis, coriaceis, lævigatis, basi rotundatis, trilobatis, lobis subæqualibus, lobo medio simulato, rotundato separato." Heer, 1882.

This species is very poorly defined, both Heer and Lesquereux including it in leaves showing a quite considerable range of

variability. They are all coriaceous, trilobate leaves of considerable size with long and stout petioles. Length 6 cm. to 10 cm. Width 7 cm to 12 cm. Lobes ovate, pointed or rounded,[1] with open rounded sinuses, the lateral lobes showing a tendency to become sublobate below. Primaries slender, camptodrome. Lesquereux makes "five nerved from the top of the petiole," a character of this species as it is in all the specimens which he figures and in one or two of Heer's figures. These extra laterals are much more slender than are the regular primaries and are not constant unless the species be considered composite.

The Coastal Plain leaves referred to this species by Newberry, Hollick and the writer are as a rule somewhat smaller in size, with narrower lobes. This species is infrequent in the Raritan, and the leaves referred to it are suggestive of what Newberry called *Aralia patens*. The species is more abundant in the somewhat later Cretaceous deposits of Marthas Vineyard and Cliffwood bluff. It was described originally from the Atane beds of Greenland and is also present in considerable abundance in the Dakota Group of Kansas.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Gardens.

ARALIA ROTUNDILOBA Newb.

Aralia rotundiloba Newb., Fl. Amboy Clays, 118, *pl. 28, f. 5; pl. 36, f. 9,* 1896.

Description.—Leaves elliptical in outline, palmately five-lobed, about 8 cm. in length, by 10 cm. in greatest breadth. Lobes all stout and rounded or slightly retuse distad, separated by shallow, rounded, open sinuses. Margins entire. Base truncate. Petiole long and very stout. Primaries comparatively slender, 3 in number, with a pair of subordinate laterals usually present. Secondaries slender, camptodrome.

As this species is based upon infrequent specimens it may possibly represent a variety of *Aralia Newberryi*, some forms

[1] Retuse in one specimen which Lesquereux refers to this species.

of which it resembles quite considerably. It is not an especially well marked species in any event, and the two forms which Prof. Newberry figures show considerable variability. Fragmentary specimens of what the writer believes to be this species are present in the collections from the Hylton Pits.

Occurrence.—Woodbridge, Hylton Pits.

Collections.—N. Y. Botanical Garden.

ARALIA PATENS Hollick.

Aralia patens Hollick, Bull. Torrey Club, vol. 21: 54, *pl. 174, f. 4,* 1894; Mon. U. S. Geol. Surv., vol. 50: 98, *pl. 38, f. 3,* 1907.

Newb., Fl. Amboy Clays, 117, *p. 37, f. 6,* 1896.

Description.—Leaves palmately trilobate, the lobes subequal, linear in outline, subacute, divergent, the lateral lobes directed transversely to the median lobe, the intervening sinuses being deep and open and forming an angle of nearly forty-five degrees. Margins entire. Base truncate. Petiole long and stout. Midrib stout. Lateral primaries, which diverge from the top of the petiole, also stout, but somewhat less so than the midrib. A subsidiary lateral of finer calibre branches from the outside point of origin of each lateral primary. Secondaries irregular, rather straight, diverging from the primaries at usually a wide angle, their ends joined by a marginal vein.

This is a rather ill-defined and infrequent species and suggests the leaf which Prof. Newberry figured as *Aralia groenlandica* Heer. A fragment has been reported by Hollick from Glen Cove, Long Island, and an equally poor fragment is contained in the present collections from South Amboy.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ARALIA FORMOSA Heer.

Aralia formosa Heer, Kreidefl. v. Moletein, 18, *pl. 8, f. 3,* 1869.
Lesq.,Cret. & Tert. Fl., 60, *pl. 11, f. 3, 4,* 1883; Fl. Dakota Group, 131, 1892.
Velen., Fl. Böhm. Kreidef., Th. *2*: *21, pl. 5, f. 2; pl. 6, f. 7; pl. 7, f. 2–4,* 1882.
Newb., Fl. Amboy Clays, 116, *pl. 22, f. 8,* 1896.

Description.—"A. foliis petiolatis, triplinerviis, trilobatis, lobis apice dentatis, obtusiusculis." Heer, 1869.

The occurrence of this species in the Raritan formation is based upon a single fragmentary specimen, figured by Prof. Newberry from South Amboy. The species was described, originally, from the Cenomanian of Moravia, and was subsequently recorded in considerable abundance from the Cenomanian of Bohemia and the Dakota Group of the west. The New Jersey material, as far as it goes, agrees very well with the more typical material from elsewhere, especially that from Bohemia. It may be distinguished from *Aralia wellingtoniana* Lesq., the only other Raritan *Aralia* which is not entire margined by the obtusely pointed lobes, always three in number, the decurrent base, and by the coarse undulate-dentate teeth.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

ARALIA WELLINGTONIANA Lesq.

Plate XXV, Fig. 7.

Aralia wellingtoniana Lesq., Fl. Dakota Group, 131, *pl. 21, f. 1; pl. 22, f. 2, 3,* 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 114, *pl. 26, f. 1,* 1896.
Aralia concinna Newb., Ibid., footnote, p. 114.

Description.—"Leaves large, coriaceous, palmately three or five lobed, narrowed in an inward curve to a prolonged base,

decurring to the petiole; lobes long, oblong-lanceolate, abruptly pointed, sharply equally dentate from above the base, the teeth turned outside or slightly upward, separated by shallow sinuses; primary nerves broad and flat; secondaries more or less oblique, slightly curving or nearly straight in passing to the borders, entering the teeth, craspedodrome, mostly simple; areolation distinctly reticulate, in irregularly quadrate or polygonal meshes."

"The leaves, which are 15 cm. to 16 cm. long, excluding the petiole, vary, of course, in width according to the number of lobes and their divergence from the median nerve, which, in most of the specimens that I have seen averages thirty-five degrees. The lobes are a little broader in the middle, slightly narrowing to the sinusus, 7 cm. to 10 cm. long, and from 2 cm. to 3 cm. broad at the middle. The separate lobe has the teeth much larger, more turned upward, appearing also of a thicker texture."

"The species is so remarkably similar to *A. Saportanea* Lesq., that at first sight it appears identical. It differs, however, by the coriaceous texture of the leaves, the reticulate areolation, the larger teeth, the more or less upwardly-turned secondaries, which are not curved or camptodrome, but run straight to the teeth and enter them; the base of the leaf is longer, decurrent, and the lobes more abruptly or obtusely pointed." Lesquereux, 1892.

This species is so well described by Prof. Lesquereux that his description is introduced *in toto* above. It is an extremely handsome species and quite different from any other form in the Raritan flora. The Raritan leaves are all trilobate, and it would seem as if the 5-lobed form was only an occasional variant, as the same species in its occurrence in the Tuscaloosa formation of Alabama is also trilobate.

There is considerable resemblance to *Aralia decurrens*, Velenovsky,[1] of the Bohemian Cenomanian, in which, however, the lobes are relatively narrower and longer, with coarser teeth and deeper sinuses.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

[1] Velenovsky, Fl. Böhm. Kreidef., Theil 3, 1884, p. 11, pl. 4, f. 5–7.

Order ERICALES.

Family ERICACEÆ.

Genus ANDROMEDA Linné.

(Sp. Pl., 1753, p. 393.)

ANDROMEDA NOVÆ-CÆSAREÆ Hollick.

Andromeda novæ-cæsareæ Hollick in Newb., Fl. Amboy Clays, 121, *pl. 42, f. 9–12, 28–31,* 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (misspelled *calcareæ*).

Berry, Bull. Torrey Club, vol. 33: 181, 1906; Ibid., vol. 34: 204, 1907.

Description.—Thick entire leaves of small size, with stout petiole and midrib and obscure secondary venation, which is for the most part immersed in the thick substance of the leafblade. Length ranging from 2.5 cm. to 5 cm. and width varying from 0.9 cm. to 1.3 cm. Venation when visible shows numerous parallel, camptodrome secondaries which branch from the midrib at an acute angle, curving upward and relatively long. While the majority of these leaves are equally acuminate at both ends, there is considerable variation in this respect, and a well-marked tendency is shown in a considerable number of specimens which are relatively broader, especially in the upper half of the leaf, toward an obtusely rounded apex, the termination of the midrib showing as a faint mucronate point. The base in these forms gradually narrows to the stout petiole, the term oblanceolate or lanceospatulate perhaps describing them better than any other. The variations in outline of this species are well shown in the figures reproduced in Prof. Newberry's monograph. A large number of the leaves which the writer has identified as this species from the Coastal Plain, south of New Jersey, have this obtusely rounded apex.

Within the Raritan formation this species is only known with certainty from the upper beds at South Amboy. It becomes

more abundant in the overlying Magothy formation and is present from New Jersey and Maryland, as well as from the Bladen formation of North Carolina, the Middendorf formation of South Carolina and the Tuscaloosa formation of Alabama. It does not appear to be especially close to either *Andromeda Snowii* Lesq. or *Andromeda linifolia* Lesq. of the Dakota Group with which Dr. Hollick has instituted comparisons. Material from North Carolina definitely proves its Ericaceous affinities.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA GRANDIFOLIA Berry.

Andromeda latifolia Newb., Fl. Amboy Clays, 120, *pl. 33, f. 6–8, 10* (non *f. 9*); *pl. 34, f. 6–11; pl. 36, f. 10,* 1896 (non Wright).

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 416, *pl. 79, f. 3,* 1904; Mon. U. S. Geol. Surv., vol. 50: 100, *pl. 39, f. 1,* 1907.

Andromeda grandifolia Berry, Bull. Torrey Club, vol. 34: 204, *pl. 15, f. 3,* 1907.

Description.—Leaves thick and coriaceous, varying considerably in size and shape. From 4 cm. to 20 cm. in length by 1.5 cm. to 7 cm. in width, ovate-lanceolate in outline, with an entire, usually somewhat undulate or unsymmetrical margin. Apex obtusely pointed or sometimes rounded. Base somewhat wedge-shaped. Midrib and petiole very stout. Secondaries relatively few, 6 to 8 eight pairs, stout and flexuous, branching from the midrib at an acute angle and sweeping upward in long curves and eventually inosculating to complete the strictly camptodrome venation.

This species occurs throughout the lower Raritan in New Jersey and at somewhat higher horizons in the Cretaceous of the Southern States. It is larger, relatively broader and less regular than *Andromeda Parlatorii* Heer, the two leaves figured on plate

23 showing the average shape with a length of about 10 cm. and a width of about 5 cm.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA COOKII Berry.

Andromeda flexuosa Newb., (non Moon, 1849) Fl. Amboy Clays, *121, pl. 34, f. 1–5,* 1896.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:416, *pl. 79, f. 2,* 1904; Mon. U. S. Geol. Surv., vol. 50: 101, *pl. 39, f. 6,* 1907.

Andromeda Cookii Berry, Bull. Torrey Club, vol. 36: 261, 1909.

Description.—Leaves coriaceous, variable in size, lanceolate in outline, 6 cm. to 12 cm. in length by 1.5 cm. to 3 cm. in width, with an acuminate apex and a somewhat cuneate base. Midrib stout and flexuous. Secondaries strong, somewhat flexuous, branching from the midrib at an acute angle and arching upward in long curves, camptodrome. Tertiaries mostly simple, transverse, forming oblong areoles.

This species is of the same general character as the other Raritan species of *Andromeda* with which it is strictly congeneric. It is a common form in the lower Raritan, although most of the specimens are imperfect. Elsewhere it is recorded from Glen Cove, Long Island, but the material from the latter locality is not very conclusive. The name given to this species by Newberry was unfortunately preoccupied, and the name here used is given in honor of the late George H. Cook, whose work on the Raritan and allied formations has furnished the basis for all subsequent studies.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA PARLATORII Heer.

Andromeda Parlatorii Heer, Phyll. Crét. d. Nebr., 18, *pl. 1, f. 5,* 1866; Fl. Foss. Arct., vol. 3, ab. 2: 112, *pl. 32, f. 1, 2,* 1874; Ibid., vol. 6, ab. 2: 79, *pl. 21, f. 1b, 11; pl. 42, f. 4c,* 1882.

Lesq., Cret. Fl. 88, *pl. 23, f. 6, 7; pl. 28, f. 15,* 1874; Fl. Dakota Group, 115, *pl. 19, f. 1; pl. 52, f. 6,* 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 120, *pl. 31, f. 1–7; pl. 33, f. 1, 2, 4, 5,* 1896.
Hollick, Ann. N. Y. Acad. Sci., vol. XI., 420, *pl. 37, f. 1–4,* 1898; U. S. Geol. Surv., Mon. 50: 101, *pl. 39, f. 2–5,* 1907.
Berry, Bull. N. Y. Bot. Garden, vol. 3: 97, *pl. 50, f. 1–4,* 1903; Bull. Torrey Club, vol. 31: 79, *pl. 1, f. 1, 2,* 1904; Ibid., vol. 33: 181, 1906; Ibid., vol. 34: 203, *pl. 15, f. 2,* 1907.

Prunus ? Parlatorii Lesq., Amer. Jour. Sci., vol. 46: 102, 1868.
Leucothoe Parlatorii Schimp., Pal. Végét., vol. 3: 11, 1874.

Description.—"A foliis lanceolatis, basi attenuatis, integerrimis, nervo medio valido, transversium striato, secundariis subtilissimis, angulo acuto egredientibus, camptodromis." Heer, 1866.

This species was first described by Prof. Heer, in one of the earliest published accounts of the Dakota Group flora, and it has since been found to have a wide geological and geographical range.

It is one of the commonest Cenomanian species occurring in Minnesota, Kansas, Nebraska, in the west, and from Greenland to Alabama, in the east. It is as common in the overlying Magothy formation as it is in the Raritan, being recorded from Marthas Vineyard, New Jersey, Delaware and Maryland. It is also present in the Bladen formation of North Carolina.

The genus *Andromeda* of Linné has been much segregated by subsequent botanists, and this is reflected in Schimper's proposal to refer this species to *Leucothoe.* However, the more general term has obvious advantages for the paleobotanist in cases like the present, where it is well-nigh impossible to segregate these various Ericaceous genera with any degree of accuracy.

Occurrence.—Newberry mentions no specific localities, but says: "Found at nearly every locality opened." I have very

good specimens from Milltown, six in all, one of which is a replica of Newberry's specimen shown on pl. 31, fig. 3. Also found at the Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order PRIMULALES.

Family MYRSINACEÆ.

Genus MYRSINE Linné.

(Sp. Pl., 1753, p. 196.)

MYRSINE BOREALIS Heer.

Myrsine borealis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 113, *pl. 32, f. 23,* 1874; Ibid., vol. 6, ab. 2: 81, *pl. 24, f. 7b, 8, pl. 27, f. 1b; pl. 44, f. 5a; pl. 46, f. 19, 20,* 1882.
White, Amer. Jour. Sci., vol., 39:98, *pl. 2, f. 5,* 1890.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 122, *pl. 24, f. 4–6,* 1896.
Hollick, Bull. Geol. Soc. Amer., vol., 7: 13, 1895; Mon. U. S. Geol. Surv., vol. 50: 102, *pl. 39, f. 10, 11,* 1907.
Diospyros rotundifolia Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 179, f. 2,* 1894.

Description.—"M. foliis ovatis (?), integerrimis, nervis secundariis numerosis, approximatis, ramosis, camptodromis." Heer, 1874.

Leaves ovate-elliptical in outline, obtusely rounded above and slightly cuneate below, 2:5 cm. to 5 cm. in length, by 1.2 cm. to 3 cm. in width, with a stout petiole about 1 cm. in length. Margins entire. Texture coriaceous, more or less obscuring the venation. Midrib stout. Secondaries mediumly stout, 5 to 8 alternate pairs, parallel, branching from the midrib at an acute angle, camptodrome. Tertiaries fine, forming an inosculating series of elongated meshes more or less parallel with the secondaries. In specimens in which the tertiary venation is visible the appearance is very

different from that shown in Prof. Newberry's figures, where only the secondaries are seen. These latter may be compared with the similarly preserved leaves from Greenland figured by Heer (*pl. 24, f. 8; pl. 44, f. 5a*).

This species was described, originally, from the Atane beds of Greenland, and was subsequently collected in considerable abundance from the Raritan formation. It has also been recorded from Marthas Vineyard and Long Island; from the Tuscaloosa formation of Alabama, and from the Bladen formation of North Carolina. It is another form which establishes the relation of the Raritan flora to the Cenomanian.

Occurrence.—South Amboy, Milltown.

Collections.—N. Y. Botanical Garden.

Myrsine oblongata Hollick.

Plate XXIV, Fig. 1.

Myrsine oblongata Hollick in Newb., Fl. Amboy Clays, 122, *pl. 42, f. 15,* 1896.

Description.—Leaves of small size, elliptical in outline, 2.6 cm. in length by 1.3 cm. in breadth. Apex broadly rounded; base almost equally so. Margins entire. Venation fine and indistinct. Secondaries 5 or 6 pairs, camptodrome.

This species was based upon a single specimen regarding which Professor Newberry failed to record the exact locality, and no additional specimens have since come to light. It is very doubtfully related to *Myrsine,* which usually has a much closer venation, and suggests a number of leaflets which have been referred to genus *Leguminosites.* As no positive light can be shed on its real affinities, it is left in the genus where it was placed by its describer.

Occurrence.—South Amboy (?).

Collections.—N. Y. Botanical Garden.

MYRSINE GAUDINI (Lesq.) Berry.

Plate XXIV, Figs 3, 4.

Myrsinites ? Gaudini Lesq., Fl. Dakota Group, 115, *pl. 52, f. 4,* 1892.

Myrsine elongata Hollick, Bull. Torrey Club, vol. 21: 54, *pl. 177, f. 2,* 1894; Ann. N. Y. Acad. Sci., vol. 11:420, *pl 38, f. 3, 4 b, c,* 1898; Mon. U. S. Geol. Survey, vol. 50: 102, *pl. 8, f. 1b; pl. 39, f. 13, 14,* 1907.

Newb., Fl. Amboy Clays, 122, *pl. 22, f. 1–3,* 1896.

Myrsine Gaudini Berry, Bull. Torrey Club, vol. 36: 262, 1909.

Description.—Leaves oblanceolate or elongate-obovate in outline, 5.5 cm. to 7 cm. in length by 1.9 cm. to 2.5 cm. in greatest width. Margins entire. Apex obtusely rounded. Base somewhat elongated, narrowly cuneate. Petiole present, stout. Midrib stout below, rapidly diminishing in calibre. Secondaries numerous, 8 to 10 pairs, alternate, branching from the midrib at angles of from 40° to 45°, camptodrome. When tertiary venation is distinctly preserved the venation is more typical than when only the secondaries are partially visible.

This species is well distributed in the Raritan and has also been recorded from Long Island and Staten Island. The identification of *Myrsinites ? Gaudini* Lesq., with the eastern forms with which it is obviously identical extends the range eastward from the Dakota Group of Kansas. It may be readily distinguished from the other Rartain species by its relatively narrow elongated form. It is also present in undescribed collections of the writer from North Carolina and Alabama.

Occurrence.—South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order EBENALES.

Family EBENACEÆ.

Genus DIOSPYROS Linné.

(Sp. Pl., 1753, p. 1057.)

DISOPYROS PRIMÆVA Heer.

Diospyros primæva Heer, Phyll. Crét. d. Nebr., 19, *pl. 1, f. 6, 7,* 1866; Fl. Foss. Arct., vol. 6, ab. 2:80, *pl. 18, f. 11,* 1882; Ibid., vol. 7:31, *pl. 61, f. 5a, b, c,* 1883.
Lesq., Fl. Dakota Group, 109, *pl. 20, f. 1–3,* 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 124, *pl. 30, f. 1–5,* 1896.
Knowlton, 21st Ann. Rept. U. S. Geol. Surv., pt. 7:317, *pl. 39, f. 3,* 1901.
Berry, Bull. Torrey Club, vol. 32:46, *pl. 2,* 1905; Ibid., vol. 34:204, 1907.
Hollick, Mon. U. S. Geol. Surv., vol. 50:103, *pl. 40, f. 2, 11,* 1907.

Description.—"D. foliis oblongo-ovalibus, integerrimis, apice obtusiusculis, nervis secundariis serpentinis, ramosis, camptodromis." Heer, 1866.

Leaves oblong-ovate in outline, variable according to age, ranging from 3 cm. to 15 cm. in length, by 1.3 cm. to 5 cm. in greatest breadth, which is in the middle part. Apex subacute or obtuse. Base cuneate. Margins entire. Petioles rather long and very stout. Midrib also stout. Secondaries branching from the midrib at usually acute angles, subopposite or alternate, parallel, camptodrome. Tertiaries forming polygonal areoles, whose relative prominence is one of the features of this species.

This species, which is quite suggestive of the modern *Diospyros virginiana* Linné, was described by Heer from the Dakota Group of Nebraska nearly half a century ago. It has proved to be a most wide-ranging form, having been identified at both the Atane

and Patoot horizons in Greenland; from various localities within the Dakota Group, including the Woodbine formation of Texas; and with the exception of the fragments from Marthas Vineyard and Long Island, which are of questionable identity, it is common in either the Raritan or Magothy or homotaxial formations from New Jersey to Alabama.

Its most marked character is the prominence of its tertiary areolation. It is abundant in the Raritan, occurring both in the older and younger beds, and is one of the species which points very strongly to the Cenomanian age of these deposits.

Occurrence.—South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Diospyros amboyensis Berry.

Phyllites ellipticus Newb., Fl. Amboy Clays, 130, *pl. 24, f. 9,* 1896.

Diospyros amboyensis Berry, Bull. Torrey Club, vol. 36: 262, 1909.

Description.—Leaves elliptical in outline, large, 8 cm. long by 4.6 cm. broad; margin undulate; apex rounded, almost retuse; base broadly rounded, thus differing from the wedge-shaped base of *Diospyros primæva;* midrib strong, although not so strong as in the latter species; secondaries numerous, 8-10 pairs, regular, leaving the midrib at an angle of about 45°, camptodrome; tertiary venation of large polygonal meshes, finer in calibre than in *Diospyros primæva.*

Unfortunately no specimens other than Newberry's original type have been found, and it is possible that it was an aberrant leaf of the common *Diospyros primæva,* some undoubted leaves of which suggest it in their sum of characters. One of the leaves which Heer identifies from the Atane schists of Greenland as *Populus hyperborea,*[1] while the apex is partially destroyed and the tertiaries are not shown, is very similar to the species under

[1] Heer, Fl. Foss. Arct., vol. 3, ab. 2; *pl. 29, f. 6, 18.*

discussion. This similarity does not extend, however, to the other leaves identified as this species.

A species of Diospyros has already been described as *Diospyros elliptica* by Knowlton, so that it becomes necessary to rename the Raritan leaf.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Calycites diospyriformis Newb.

Plate XXIX, Figs. 2–4.

Calycites diospyriformis Newb., Fl. Amboy Clays, 132, *pl. 46, f. 39–41,* 1896.

Description.—Calyx-like organism, 10 mm. to 12 mm. in width, consisting of a central portion 4 mm. or 5 mm. in diameter, marked at its center by a small circle about 1 mm. across, which is the abscission scar where the calyx became detached from the peduncle. From the central portion there radiates marginally five subequal, rapidly narrowing, sepal-like, pointed lobes.

In every aspect these objects suggest the persistent calyx of modern species of *Diospyros* as well as various similar fossil specimens which have been referred to this genus, and they may well represent the calyx of a contemporary species of that genus, possibly the abundant *Diospyros primæva* Heer.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order GENTLANALES.

Family ASCLEPIADACEÆ.

Genus ACERATES Elliott.

(Bot. S. C. & Ga., vol. 1 : 316, 1817.)

ACERATES AMBOYENSIS Berry.

Acerates sp., Hollick in Newb., Fl. Amboy Clays, 124, *pl. 32, f. 17; pl. 41, f. 4, 5,* 1896.
Berry, Bull. Torrey Club, vol. 34:205, 1907.
Acerates amboyensis Berry, Ibid., vol. 36:263, 1909.

Description.—Leaves narrow and elongated, somewhat falcate, lanceolate or linear-lanceolate in outline, 5 cm. to 7.5 cm. in length by 5 mm. to 8 mm. in breadth, gradually narrowed above and cuneate below. Margin entire, somewhat undulate. Petiole apparently wanting. Texture thick. Secondaries numerous, rather angular, branching from the midrib at acute angles, camptodrome.

There is no reason why this species should not have a specific name, if only for purposes of intelligent citation. It is, moreover, perfectly distinct from the other members of the Raritan flora and is easily recognized. It is confined to the Upper Raritan in New Jersey, but occurs in the Bladen formation of North Carolina. Several species of *Acerates* are described by Heer from the Greenland Cretaceous.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

INCERTÆ SEDIS.

Genus CALYCITES Massalongo.[1]

(Schizzo Geog., 1850, p. 72.)

CALYCITES PARVUS Newb.

Calcyites parvus Newb., Fl. Amboy Clays, 131, *pl. 46, f. 28, 29,* 1896.

[1] A single Raritan species of *Calycites* is placed in its proper botanical position under *Diospyros.*

Description.—Calyx-like organisms of small size, with 5 radiating, short and rounded sepals (?) from the disk-like central portion, the whole 6 mm. to 7 mm. in diameter.

The botanical affinity of these calyx-like organisms is entirely a matter of speculation. That they are the remains of flowers of some member of the Raritan flora seems quite probable. They are so small and rare that they are often likely to escape observation altogether.

A number of supposed floral remains have been grouped under this genus, but it would be profitless to discuss any of them in this place.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CARPOLITHUS Allioni.

(Oryct. Pedemont, Sp., 1757, p. 6.)

CARPOLITHUS PRUNIFORMIS Newb.

Carpolithus pruniformis Newb., Fl. Amboy Clays, 133, *pl. 46, f. 42,* 1896.

Description.—Organisms of small size, somewhat irregular in shape, ovoid, pointed at both ends, longitudinally striated. Found either singly or united in pairs at their ends by a comparatively long narrow neck. Length about 1.5 cm. Breadth 7 mm.

These objects, which evidently represent the fruits of some Raritan plant, are of unknown affinity. They are not rare at the Woodbridge locality, and suggest the pods of some leguminous plant, numbers of which normally bear such pods, while similar pods occur in other genera, as, for example, in *Robinia,* where the normal pods are of the ordinary canoe-shape. They are also remotely suggestive of the tubers of *Equisetum,* which are so often found in the fossil state.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Carpolithus floribundus Newb.

Carpolithus floribundus Newb., Fl. Amboy Clays, 133, *pl. 46, f. 17–21,* 1896.
Hollick, Mon. U. S. Geol. Surv., vol. 50: 110, *pl. 7, f. 20, 21,* 1907.

Description.—Capsules broadly ovate in outline and elliptical in cross-section, 5 mm. to 8 mm. in length, by 3 mm. to 6 mm. in breadth, apparently 5-chambered and dehiscing at the apex. Before dehiscence the apex appears sharply pointed, afterward the fossils, as preserved, show from 2 to 5 sharp teeth. These capsules occur singly, sometimes attached to a rather stout peduncle, in other instances they are preserved in pairs, and Newberry figures one specimen (loc. cit., *f. 19*) in which the capsule-bearing branches are apparently dichotomously arranged.

These objects occur in considerable abundance at Woodbridge, N. J., and they are also recorded, by Hollick, from Gay Head, Marthas Vineyard. Their botanical affinity is unknown.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Carpolithus hirsutus Newb.

Carpolithus hirsutus Newb., Fl. Amboy Clays, 134, *pl. 46, f. 14, 14* a, 1896.
Hollick, Mon. U. S. Geol. Surv., vol. 50: 110, *pl. 7, f. 3–8,* 1907.
Carpolithus spinosus Hollick, Bull. Geol. Soc. Amer., vol. 7: 13, 1895.

Description.—Fruits obovate to elliptical in outline, 1 cm. to 1.5 cm. in length, by 0.6 cm. to 1 cm. in breadth, attached to a stout peduncle, 1 cm. long, in one specimen. Ornamented with a corona of prickle-like spines, in various states of preservation, sometimes complete, tapering and sharply pointed, about 2.5 mm.

in length; these must have been of considerable consistency to assure their preservation.

These objects, which seem to represent bilocular capsules or twincarpels, are common in the clays at Woodbridge, N. J., and are also recorded in considerable abundance from Gay Head, Marthas Vineyard. Their botanical relations are unknown.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

CARPOLITHUS OVÆFORMIS Newb.

Carpolithus ovæformis Newb., Fl. Amboy Clays 134, *pl. 46, f. 15, 16,* 1896.

Description.—Fruits ovate or slightly obovate in outline, apparently representing a rather thick-walled capsule, 1.2 cm. to 2 cm. in length by 0.6 cm. to 1 cm. in breadth, with a pointed apex and a rounded base. Peduncle short and stout, curved.

These objects are uncommon at the Woodbridge locality and their botanical relationship is problematical.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

CARPOLITHUS WOODBRIDGENSIS Newb.

Carpolithus woodbridgensis Newb.. Fl. Amboy Clays, 133, *pl. 46, f. 22,* 1896.

Description.—Fruits or seeds, 9 mm. to 10 mm. in length by 3 mm. to 4 mm. in diameter, elliptical in shape and with fine longitudinal striations.

These forms are of somewhat infrequent occurrence at the Woodbridge locality and of unknown botanical relationship.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CHONDROPHYLLUM Necker.

(Elem. Bot., vol. II., 1790, p. 347.)

CHONDROPHYLLUM OBOVATUM Newb.

Chondrophyllum obovatum Newb., Fl. Amboy Clays, 118, *pl. 42, f. 26, 27,* 1896.

Description.—Leaves small, orbicular or obovate in outline, 1.3 cm. to 2.6 cm. in length, by 1 cm. to 2 cm. in greatest breadth, which is the upper half of the leaf. Margins entire. Apex rounded, sometimes slightly emarginate. Base more or less cuneate. Midrib slender, much attenuated. Secondaries slender, about six pairs, branching at acute angles, camptodrome. Areolation polygonal.

These leaves form an inconspicuous element in the Raritan flora and there is very little ground either for or against their reference to *Chondrophyllum.* The genus is poorly defined and its relations are problematical. It seems very probable that it is composite and its relations have been thought to be with the Vitaceæ and the Araliaceæ. One species at least, as the writer will show in his description of the North Carolina Cretaceous flora, is not a dicotyledon at all, but is clearly allied with the modern monocotyledonous genus *Pistia.*

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

CHONDROPHYLLUM RETICULATUM Hollick.

Chondrophyllum reticulatum Hollick in Newb., Fl. Amboy Clays, 119, *pl. 41, f. 6, 7,* 1896.

Description.—Leaves delicate, apparently broadly orbicular in outline, 3 cm. to 3.5 cm. in length by 3 cm. to 4 cm. in breadth, with broadly rounded apex and a cuneate base. Petiole present, stout. Midrib slender. Secondaries 4 to 5 alternate pairs, parallel, slender, branching at an acute angle, camptodrome, distally merging in the tertiary reticulations.

This species was based upon imperfect specimens which somewhat resemble *Chondrophyllum orbiculatum* Heer. No additional material is contained in the recent collections and the original locality for the type remains unknown.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus FONTAINEA Newb.

(Fl. Amboy Clays, 1896, p. 94.)

FONTAINEA GRANDIFOLIA Newb.

Fontainea grandifolia Newb., Fl. Amboy Clays, 96, *pl. 45, f. 1–4,* 1896.

Description.—Leaves may be regarded as bilobate or as dichotomously compound with bilobate leaflets. The latter are markedly unsymmetrical, linear-lanceolate in outline. Distally they are narrowed and obtusely pointed. The base is markedly unsymmetrical, one margin decurring for a distance of from 1 cm. to 2 cm. below the opposite margin. The extremely stout midrib (or common winged petiole of a double leaf) runs straight for a distance of 5 cm. to 6 cm., at which point it forks dichtomously at an acute angle, the two stout branches running to the tips. Internally this fork is naked for a distance of 2 cm. to 3 cm. of each limb, from which point the inner laminæ of the lobes curve out until the lobe becomes equilateral or even broader on its inner lamina. The secondary venation is fine; the secondaries, which are numerous and parallel, branch at a very large angle and become lost in the leaf substance toward the margin, although they seem to be camptodrome in their final course.

In discussing these peculiar fossils, which are not uncommon at the Woodbridge locality, Prof. Newberry compares them with *Haliserites Reichii*[1] reproducing Sternberg's figure on plate xiv., fig. 5. This plant, which came from the greensand of Niederschœna in Saxony (Cenomanian) was discovered by Reich and named *Fucoides dichotomus.* Sternberg referred it to *Haliser-*

[1] Sternberg, Fl. d Vorwelt 2: 34, *pl. 24, f. 7.*

ites because of its fancied resemblance to a recent alga, *Haliseris polypodoides* Ag. This plant is hardly a seaweed and seems to be congeneric with the Raritan plant. It was, however, much smaller and differed in other particulars.

Another similar form is figured by Bronn[1] as *Haliserites Reichii* and described by Rossmassler and Cotta as a *Chiropteris*. Schimper[2] refers it to the genus *Delesseria* because of its resemblance to the modern *Delesseria ruscifolia* Ag. This plant also is scarcely a seaweed, in fact, Rothpletz has recently proposed calling it *Phyllites Reichii*[3]. It is exceedingly close to *Fontainea* and is probably a dicotyledon. Still another similar plant is the one described from the Cenomanian of Bohemia by Velenovsky as *Aralia furcata*[4]. This undoubtedly belongs to the same genus as the New Jersey plant and is compared by its describer with the genera *Jatropha, Vitex, Cussonia,* etc. It can hardly be regarded as belonging to the genus *Aralia*.

Prof. Newberry states his preference for a relationship with *Hymenaea* and *Bauhinia* and regards the genus *Sapindopsis* from the older Potomac as related to the Raritan plant. The two are entirely distinct, however, and the Raritan plants must remain for the present, at least, in the form genus *Fontainea,* to which Prof. Newberry referred them.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEWBERRYANA gen. nov.

NEWBERRYANA RIGIDA (Newb.) Berry.

Hausmannia rigida Newb., Fl. Amboy Clays, 35, *pl. 1, f. 2, 3, 5,* 1896.

Description.—"Frond large, bipinnate or tripinnate, flat; central line of pinnæ and pinnules traversed by a strong, continuous

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[1] Lethaea Geognostica, *pl. XXVIII, Fig. 1.*
[2] Pal. Végét, I: 178 and 185, 1869.
[3] Rothpletz, Zeits. deutsch. geol. Gessell., vol. 48: 904, 1896.
[4] Fl. Böhm. Kreidef. Th. 3: 13, *pl. 4, f. 1,* 1884 (*Aralia elegans*).

midrib, from which are given off many fine flexuous, branching veins. Margins entire, pinnæ and pinnules mostly opposite, pinnules linear, subacute." Newberry, 1896.

The above is Professor Newberry's characterization of this interesting plant, which he refers to the Hepaticæ. It is, obviously, not related to the genus *Hausmannia*, Dunker, which has been definately proven to be a fern genus[1] of the family Dipteriaceæ, so that I have ventured to propose a new generic name, selected in honor of Prof. Newberry. What its real nature is, I am at a loss to say. It is probably a fern, but as its botanical affinity remains uncertain, I have placed it among the Raritan forms of unknown botanical affinities, since there are no grounds for retaining it in the Hepaticæ.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Genus TRICALYCITES Hollick.

(Bull. Torrey Club, vol. 21, 1894, p. 63.)

TRICALYCITES PAPYRACEUS Hollick.

Tricalycites papyraceus Hollick, Bull. Torrey Club, vol. 21 : 63, *pl. 180, f. 8,* 1894; Ann. N. Y. Acad. Sci., vol. 11 :61, *pl. 3, f. 6,* 1898; Ibid., 423, *pl. 37, f. 1, 2;* Bull. N. Y. Bot. Garden, vol. 2 :405, *pl. 41, f. 3,* 1902; Mon. U. S Geol. Surv., vol. 50 :109, *pl. 5, f. 8–12,* 1907; 55th Ann. Rept. N. Y. State Mus., 1901 (1903) p. r51.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 132, *pl. 46, f. 30–38,* 1896.

Berry, Bull. Torrey Club, vol. 31 :81, *pl. 1, f. 4,* 1904.

Description.—Well defined organisms, apparently dicotyledonous in their affinities and involucral or bracteate in their nature. They consist of a central nucleus which is usually of small size, that is to say, 1 mm. to 3 mm. in diameter, borne at the apex of a stout peduncle or stalk, 2 mm. to 5 mm. in length. To

[1] Richter, Die Gattung Hausmannia Dunker, Liepzig, 1906.

this nucleus three membraneous wings are usually attached. These wings usually diverge from each other at angles of about 45°; they are broadly linear, obovate or ovate in outline, with broadly rounded, almost truncate tips and narrowed somewhat toward the base, the lateral wings being usually somewhat unsymmetrical; they are marked by fine parallel longitudinal veins converging toward the base and anastomosing at intervals. In size they range from 0.5 cm. to 2.5 cm. in length by 2 mm. to 10 mm. in width. Both Hollick and Newberry call attention to the somewhat greater length of the middle wing, which is, however, far from being a constant character since some specimens fail to show it, all of the wings being of similar size, or the central wing may even be much smaller, as it is in some of the Alabama material, where, along with the normal forms, there occur others with all of the wings directed upward and the central one only about half the size of the laterals.

The botanical relation of these curious objects remains unknown, although they are probably comparable to the bracts so largely developed in some of the Juglandaceæ and Betulaceæ, or to certain of the winged fruits to be found among the modern Sapindaceæ or Dipterocarpaceæ. In the abundant remains from Tottenville, Staten Island; Gay Head and Nashaquitsa, Marthas Vineyard, and Glen Cove, Long Island, Dr. Hollick has described another species, *Tricalycites major*[1] based on forms which are usually two winged and with a larger nucleus, the wings reaching a length of 4 cm. and a width of 1.3 cm. The same author has described similar but smaller remains from Marthas Vineyard as *Calycites obovatus*[2] and still smaller remains from Montauk Point as *Calycites alatus*[3]. While perhaps from the standpoint of the paleobotanist these segregations are permissible or even desirable, it may be doubted if they express real specific distinctions and not merely individual variations. There is certainly a suggestion in the forms from the Tuscaloosa formation of Alabama, which occur with the normal *Tricalycites papyraceous*, that

[1] Hollick, Mon. U. S. Geol. Surv., vol. 50, 1907, p. 108, *pl. V, figs. 13–22*.
[2] Ibid., p. 109, *pl. V, fig. 23*.
[3] Ibid., p. 109, *pl. V, fig. 24*.

the central wing may be more or less abortive or completely so, in which instance we get some terms of the series leading to *Tricalycites major* or to the almost identical smaller forms which are referred to *Calycites obovatus* and *alatus*.

Tricalycites papyraceous is abundant at Woodbridge, and also occurs in the upper Raritan at South Amboy. It occurs sparingly at Cliffwood bluff, N. J., and is abundant in the insular Cretaceous floras and that of the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Genus TRICARPELLITES Bowerbank.

(Hist. Foss. Fr. & Seeds, London Clay, 1840, p. 76.)

†TRICARPELLITES STRIATUS Newb.

Tricarpellites striatus Newb., Fl. Amboy Clays, 132, *pl. 46, f. 9–13*, 1896.
Hollick, Mon. U. S. Geol. Surv., vol. 50: 108, *pl. 7, f. 1*, 1907.

Description.—Fruit-like objects, irregularly ovoid in shape, 2.5 cm. to 4 cm. in length, and about 2 cm. in diameter, apparently enclosed in a longitudinally striated husk, pointed above, rounded below, grouped in threes at the summit of a stout stem.

These objects are of characteristic appearance, and are quite common in the Raritan formation at the Woodbridge locality. Their botanical affinity is entirely conjectural, and they are wholly confined to New Jersey, except for a single, very poorly defined specimen, reported by Hollick, from Marthas Vineyard.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus VIBURNUM Linné.

(Sp. Pl., 1753, p. 267.)

VIBURNUM INTEGRIFOLIUM Hollick.

Viburnum integrifolium Hollick, Bull. Torrey Club, vol. 21 : 54, *pl. 177, f. 7*, 1894; Mon. U. S. Geol. Surv., vol. 50: 105, *pl. 40, f. 1*, 1907.

Newb., Fl. Amboy Clays, 125, *pl. 41, f. 1*, 1896.

Description.—Leaves of large size, broadly ovate in outline, about 11 cm. or 12 cm. in length, by 7.5 cm. in greatest breadth, which is toward the middle of the leaf. Apex pointed (?). Base rounded (?). Margins entire. Midrib stout. Secondaries also stout, 5 or 6 pairs, subopposite, camptodrome, branching from the midrib at an acute angle and curving upward, connected by numerous straight, transverse tertiaries, which are mostly obsolete.

This species was based on a single, imperfect specimen, which Prof. Newberry referred to the genus *Viburnum*, comparing it with the modern *Viburnum lantanoides*, which it does not resemble in the least degree. An additional fragmentary specimen has been described by Hollick from Glen Cove, Long Island, which is sufficient to show that the base was pointed or rounded and not cordate as suggested by Newberry.

There is absolutely no ground for its reference to *Viburnum*, but rather than attempt a re-identification with such incomplete material as a basis, Prof. Newberry's name is retained and the specimen is placed with those of unknown affinities, instead of in the place where *Viburnum* would come in the natural system.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus WILLIAMSONIA Carruthers.

(Trans. Linn. Soc. Lond., vol. XXVI, 1868, p. 680.)

WILLIAMSONIA SMOCKII Newb.

Williamsonia Smockii Newb., Fl. Amboy Clays, 127, *pl. 36, f. 1–8*, 1896.

Description.—Indefinite floral or fruit-remains of variable size. 2.5 cm. to 4 cm. long, by 2.5 cm. to 3 cm. in diameter, cylindrical, apparently cupshaped, and with a simple margin, which may be slightly expanded or contracted; narrowing below to a comparatively slender peduncle. Base and peduncle apparently covered with scales or small bracts, although the preservation is such that this is rather inferential.

Prof. Newberry sees in these objects a not altogether obvious resemblance to *Williamsonia cretacea* Heer. They may be related to the Cycadales, but this supposition is far from positive, and they are retained in the genus to which Prof. Newberry referred them, rather than make a change based upon the slender evidence available. They are said to be common in the Raritan, several specimens having been figured by their describer, who failed, however, to record the exact locality, and no new material is contained in the more recent Raritan collections.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

WILLIAMSONIA PROBLEMATICA (Newb.) Ward.

Palæanthus problematicus Newb., Fl. Amboy Clays, 125, *pl. 35, f. 1–9,* 1896.

Williamsonia problematica Ward, 15th Ann. Rept. U. S. Geol. Surv. 382, 1895.

Hollick, Mon. U. S. Geol. Surv., vol. 50:107, *pl. 5, f. 27–32,* 1907.

Description.—Fructifications consisting of a long and stout peduncle preserved for a length of 2 cm. to 3 cm. and about 7 cm. in diameter, expanding distally into a discoid conical receptacle, the edge of which is surmounted by 10 to 20 lanceolate bracts 1.5 cm. to 3.5 cm. in length and 2 mm. to 10 mm. in diameter, the whole of a very durable consistency.

These objects are present in considerable abundance in the Raritan clays, and Prof. Newberry figures a number of specimens, although he neglects to mention the localities from which they

were collected. He seems disposed to attach considerable weight to their resemblance to a helianthoid flower, and points out that they differ from the typical Williamsonias in the apparent absence of the internal seed-bearing cone. The nature of the remains does not enable one to form a positive opinion, nevertheless their resemblance to well-preserved Williamsonias which are undoubtedly cycadean, lends more support to a theory of relationship with the latter group of plants than with the essentially modern Compositæ. The increased interest in the Cycadales called forth in recent years, has served to establish the cycadean affinity of a number of species of Williamsonia, and structural material has in a measure cleared up their morphology, so that while this order of plants had commenced its final decline in Raritan time, it must be remembered that it was exceedingly abundant in the older Cretaceous deposits of Maryland and Virginia, and remnants of cycad fronds are by no means uncommon in the Raritan deposits.

Many supposed Williamsonias have been described, most of those from American rocks being founded upon exceedingly imperfect material. Perhaps the form most like the present species is *Williamsonia delawarensis* Berry[1] described from the Magothy formation of Delaware. It may be questioned if the forms from Marthas Vineyard which Hollick (loc. cit.) refers to ***Williamsonia problematica*** are not more properly referable to *Williamsonia delawarensis*. This is especially true of this author's figures 29 to 32, while figures 27 and 28 may be lateral views of the compressed transverse views of the objects described as ***Williamsonia Riesii***. From nearly homotaxial horizons ***Williamsonia elocata*** has been described by Lesquereux[2] from the Dakota sandstone, and *Williamsonia cretacea* has been described from the Atane beds of Greenland by Heer[3]. The Williamsonias described by Ward from the older Cretaceous are all extremely poor and of doubtful affinities, but ***Williamsonia virginiensis*** described by Fontaine from the older Potomac of Virginia, is

[1] Johns Hopkins Univ. Circulars, No. 199. 1907. p. 84. *f. 4.*

[2] Lesq., Fl. Dakota Group, 87. *pl. 2. f. 9. 9a.* 1892.

[3] Heer, Fl. Foss. Arct., vol. VI, Abth. 2: 59. *pl. 12. f. 1: pl. 13, f. 9.* 1882.

well preserved and characteristic, and can scarcely be anything but the remains of a cycadean fructification.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus PHYLLITES Sternberg.[1]

(Fl. d. Vorw., vol. I, 1823, p. 39.)

PHYLLITES TRAPAFORMIS sp. nov.

Plate XX, Figs. 1, 2.

Description.—Leaf very small, elliptical in outline, 6 mm. in length, by 4 mm. in greatest width, which is about half way between the apex and the base. Petiole missing (if ever present). Base evenly rounded. Margin entire in the lower half of the leaf, but broken to form five relatively large dentate teeth distad, the central one, which is the largest and most prominent, constituting the pointed apex of the leaf. Outside lateral teeth smallest, and separated by a rounded sinus from the inside lateral teeth, which, in turn, are separated from the apical tooth by shallow angular sinuses. Venation delicate, consisting of a thin midrib and craspedodrome secondaries branching from near the base on each side and running to the lateral teeth. From these there branch, from near their point of insertion on the outer side, camptodrome veins of the same calibre. Shorter, inwardly-directed veins branch higher up. There are one or two thinner camptodrome marginal veins deployed along the lower outer margin of the leaf.

This well-characterized little leaf, if it is a leaf, suggests various existing leaflets, such as those of *Spiræa, Thalictrum,* etc., as well as the floating leaves of some Cretaceous species allied with the modern genus *Trapa*. There is the further possibility that the present form may represent either a floral or vegetative bract of some Cretaceous species of unknown botanical affinity,

[1] Since the type of this useful form-genus is probably a species of *Populus,* it is probable that it will eventually have to be abandoned.

and for this reason it has been placed in the comprehensive form-genus *Phyllites*.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

PHYLLITES UNDULATUS Newb.

Phyllites undulatus Newb., Fl. Amboy Clays, 131, *pl. 24, f. 10,* 1896.

Description.—Leaf large, broadly elliptical in outline, apparently about 7 cm. in length, by 6 cm. in greatest breadth. Apex broadly rounded. Base destroyed. Margin pronouncedly undulate. Venation fine, but distinct. Midrib slender and flexuous. Secondaries remote, about five pairs, alternate, branching at an acute angle, curved, camptodrome.

This species is unfortunately based upon a single specimen, which lacks the basal portion. It is obviously distinct from the other forms known from the Raritan formation, although it may possibly be an aberrant leaf of *Celastrophyllum undulatum*, Newb. Since, however, this cannot be conclusively proven, it is here retained in the ambiguous genus *Phyllites,* to which it was assigned by Prof. Newberry.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

INDEX.

Names in italics are *Synonyms*.

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PLATES.

Fig. 1.—The Woodbridge clays, Cutter's Pit, Woodbridge.

Fig. 2.—Woodbridge clays, showing eroded upper surface.

Fig. 1—Cross bedded Raritan sand near Florida Grove.

Fig. 2—Raritan Sand ("feldspar") overlying Woodbridge Clay.

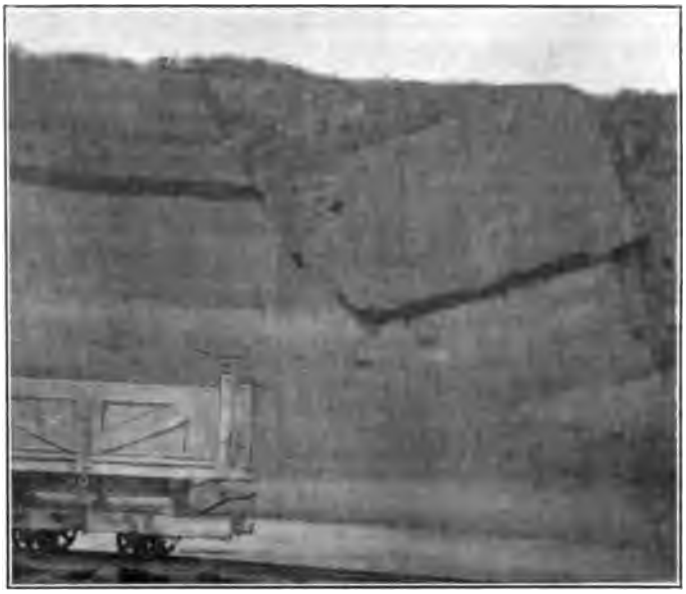

Fig. 1.—Woodbridge clay with seam of lignite, near Florida Grove.

Fig. 2.—Fire clay and fireproofing clay, north of Keasbey.

Fig. 1—Dicksonia groenlandica Heer, Woodbridge.

PLATE V.

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Figs. 1, 2—Asplenium Foersteri Deb. & Ett., Woodbridge.
Figs. 3, 4—Asplenium Dicksonianum Heer, Woodbridge.

PLATE VI.

1 *Figs. 1–5*—Sequoia heterophylla Velen., South Amboy. 5

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Figs. 1–4—Brachyphyllum macrocarpum Newb., South Amboy.

PLATE VIII.

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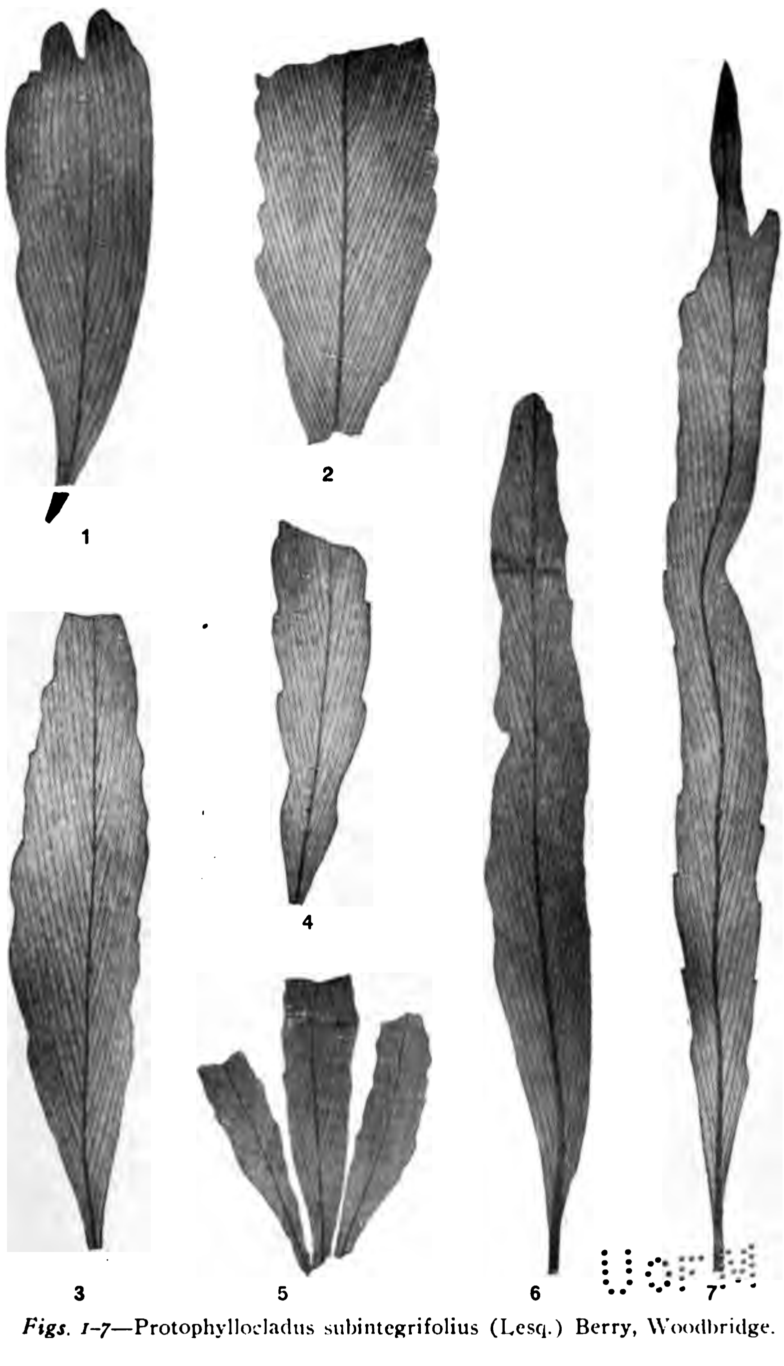
Figs. 1, 2.—Widdringtonites Reichii (Ett.) Heer, South Amboy.
Figs. 3–6.—Moriconia cyclotoxon Deb. & Ett., South Amboy.

PLATE IX.



Figs. 1–7—Protophyllocladus subintegrifolius (Lesq.) Berry, Woodbridge.

PLATE X.

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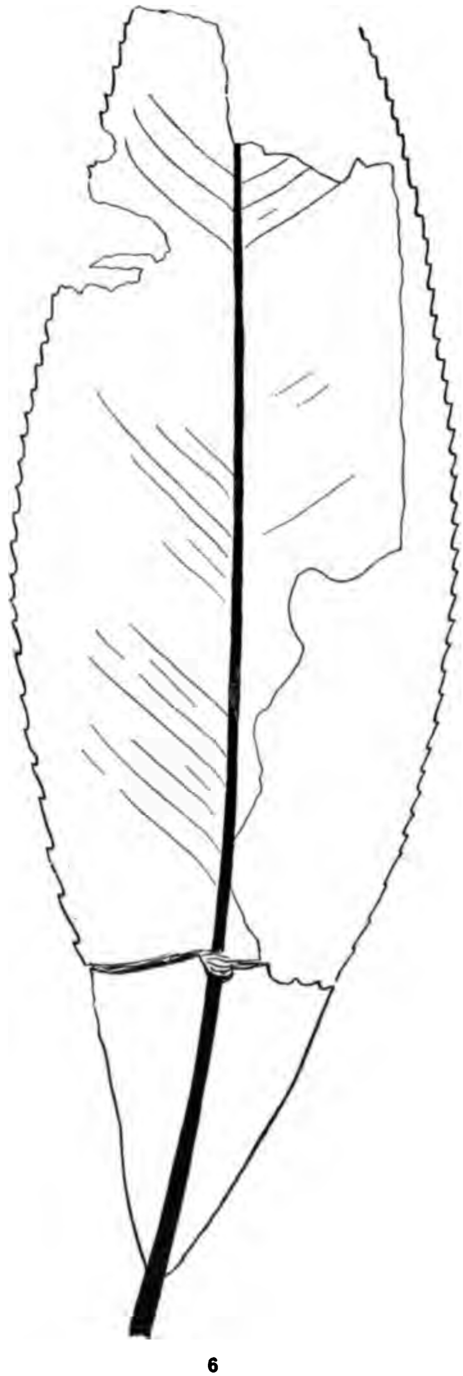

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Fig. 1.—Myrica acuta Hollick, locality unknown. *Fig. 2.*—Myrica Newberryana Hollick, South Amboy. *Fig. 3.*—Myrica fenestra Newb., Sayreville. *Fig. 4.*—Myrica raritanensis Hollick, locality unknown. *Fig. 5.*—Myrica emarginata Heer (?), locality unknown. *Fig. 6.*—Myrica Hollicki Ward, Milltown. Fig. 7.—Myrica cinnamomifolia Newb., Woodbridge.

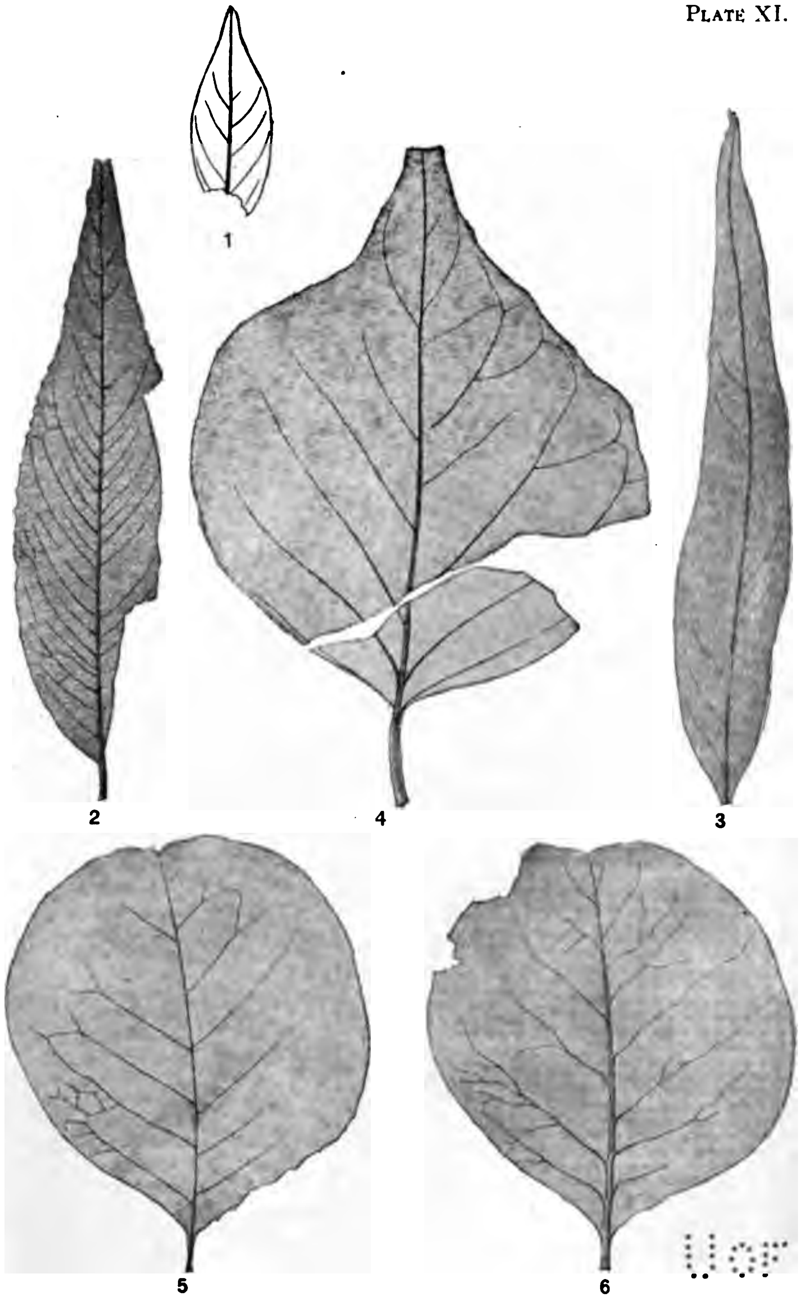
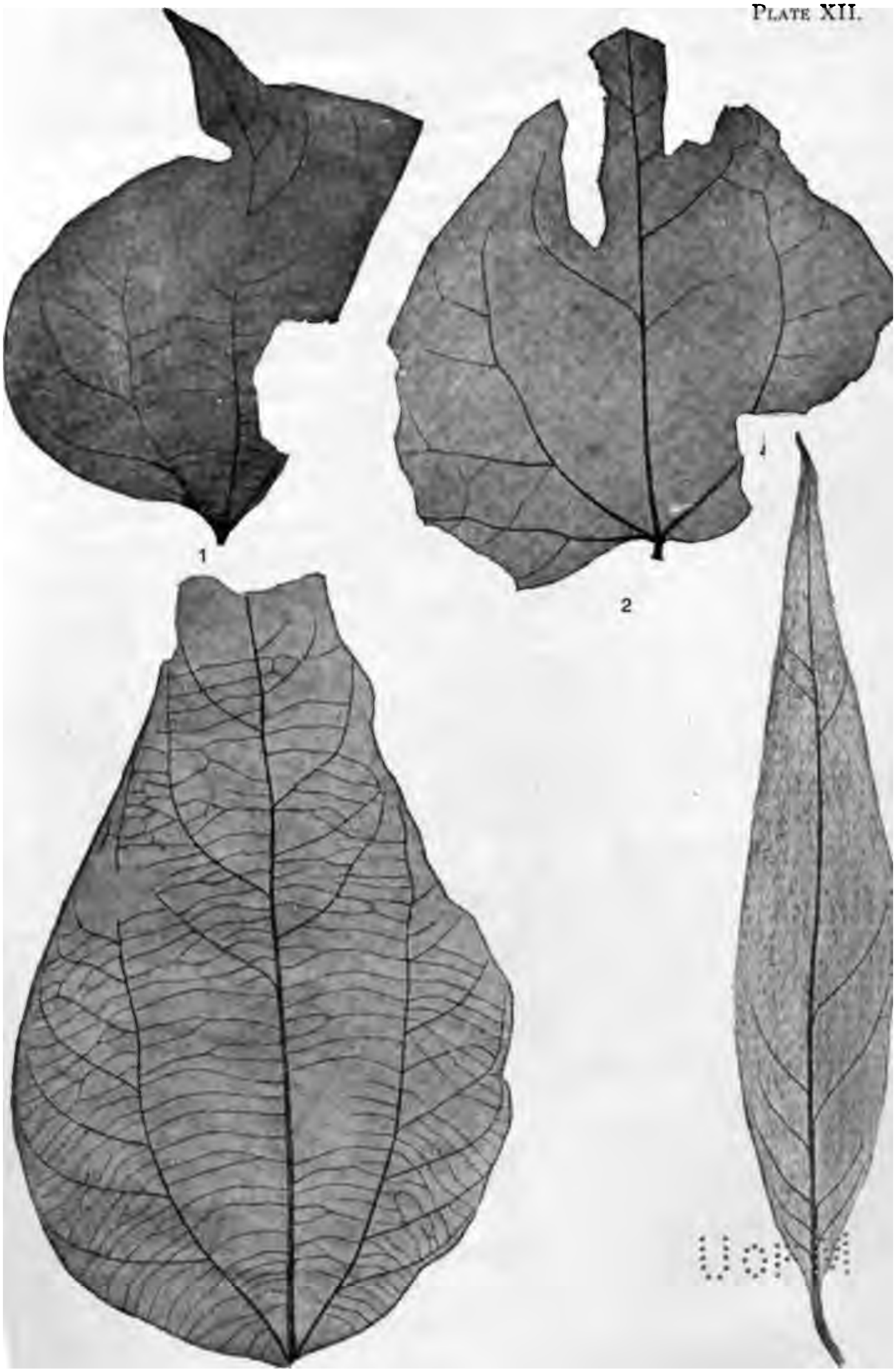


Fig. 1.—Salix pseudo-Hayei Berry, Milltown.
Fig. 2.—Salix Newberryana Hollick, South Amboy.
Fig. 3.—Salix inæqualis Newb., Woodbridge.
Fig. 4.—Populus apiculata Newb., Woodbridge.
Figs. 5, 6.—Populus orbicularis (Newb.) Berry, Sayreville.



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Figs. 1, 2.—Ficus Woolsoni Newb., Woodbridge.
Fig. 3.—Ficus ovatifolia Berry, Woodbridge.
Fig. 4.—Ficus daphnogenoides (Heer) Berry, Woodbridge.

PLATE XIII.

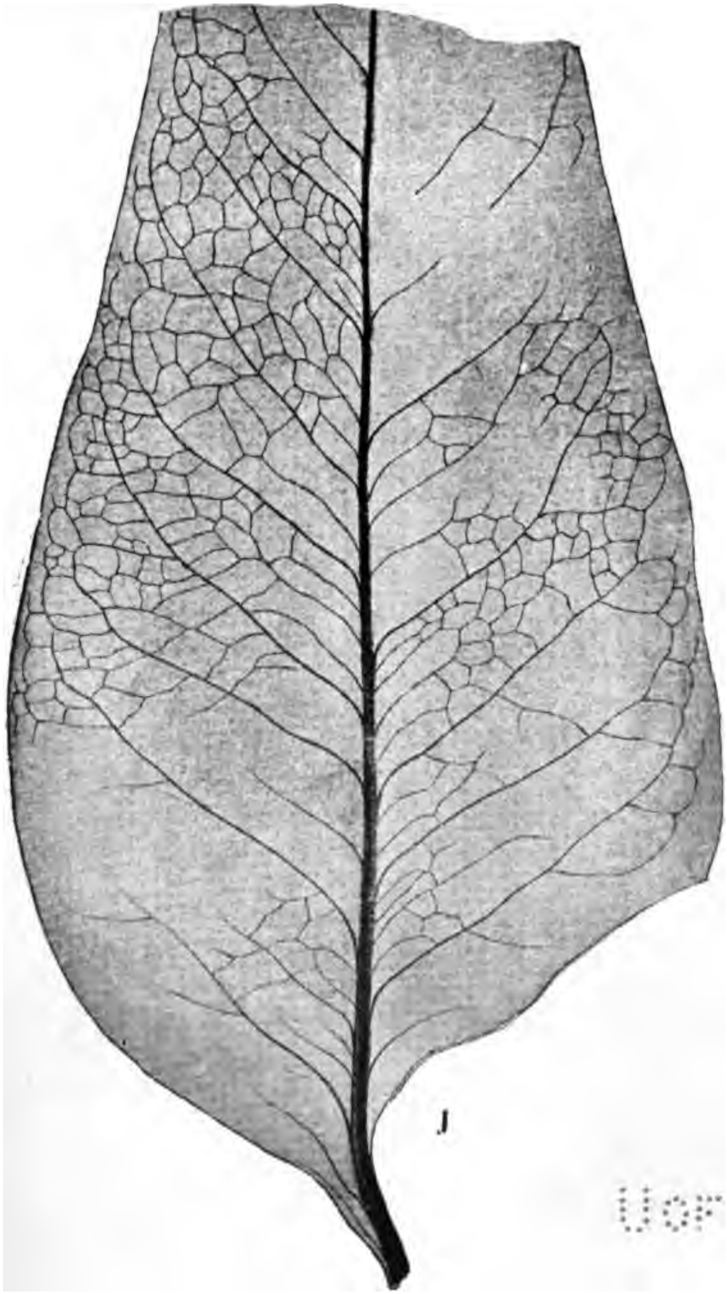

Fig. 1.—Magnolia Newberryi Berry, Woodbridge.

PLATE XI

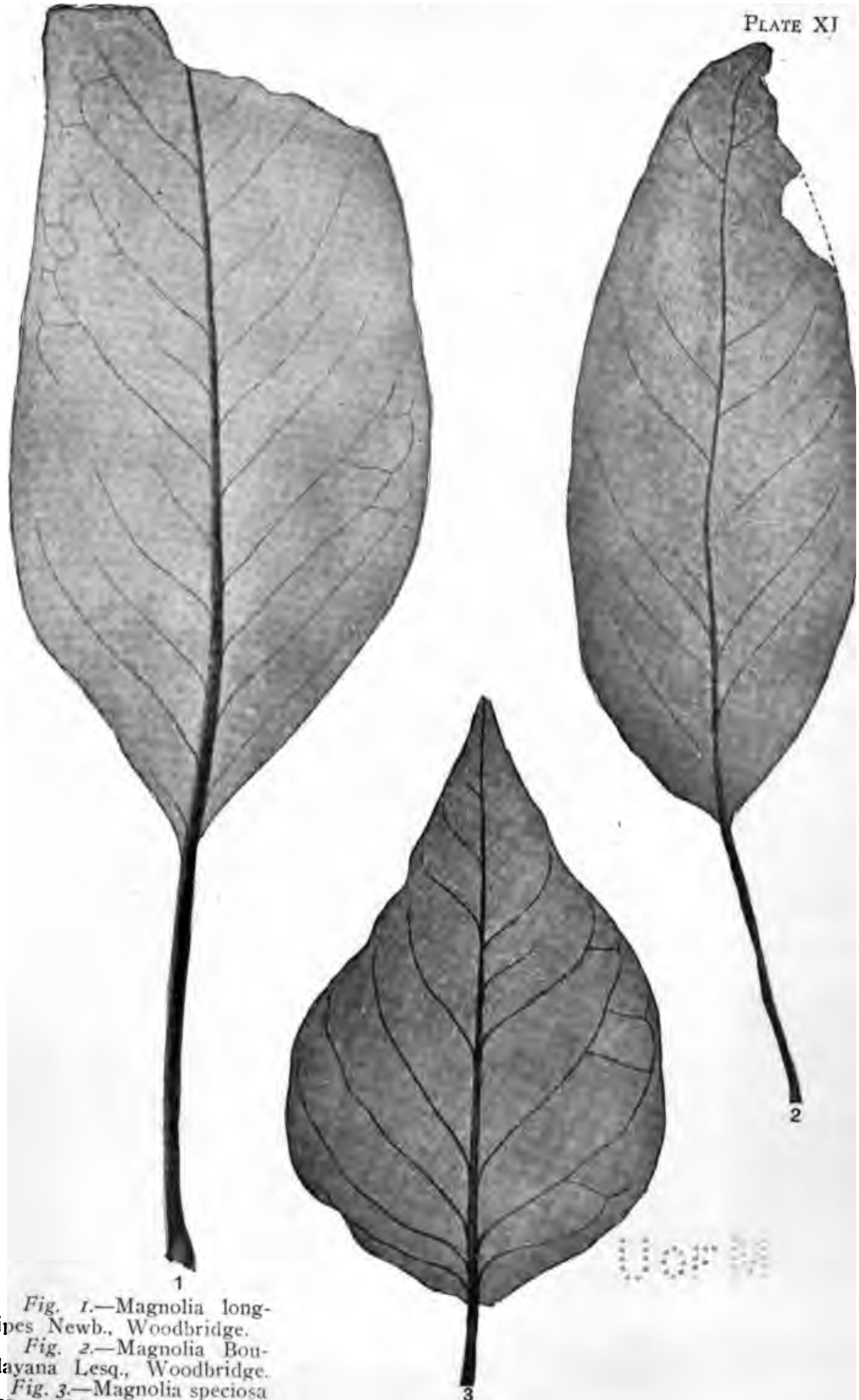

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Fig. 1.—Magnolia longipes Newb., Woodbridge.
Fig. 2.—Magnolia Boulayana Lesq., Woodbridge.
Fig. 3.—Magnolia speciosa Heer. Woodbridge.

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Fig. 1.—Magnolia alternans Heer (?), Woodbridge.
Fig. 2.—Magnolia woodbridgensis Hollick, Woodbridge.
Fig. 3.—Magnolia Hollicki Berry, Woodbridge.

Fig. 1.—Magnolia Hollicki Berry, Woodbridge.
Fig. 2.—Magnolia Lacœana Lesq., Woodbridge.
Fig. 3.—Cinnamomum Newberryi Berry, Woodbridge.

PLATE XVII.

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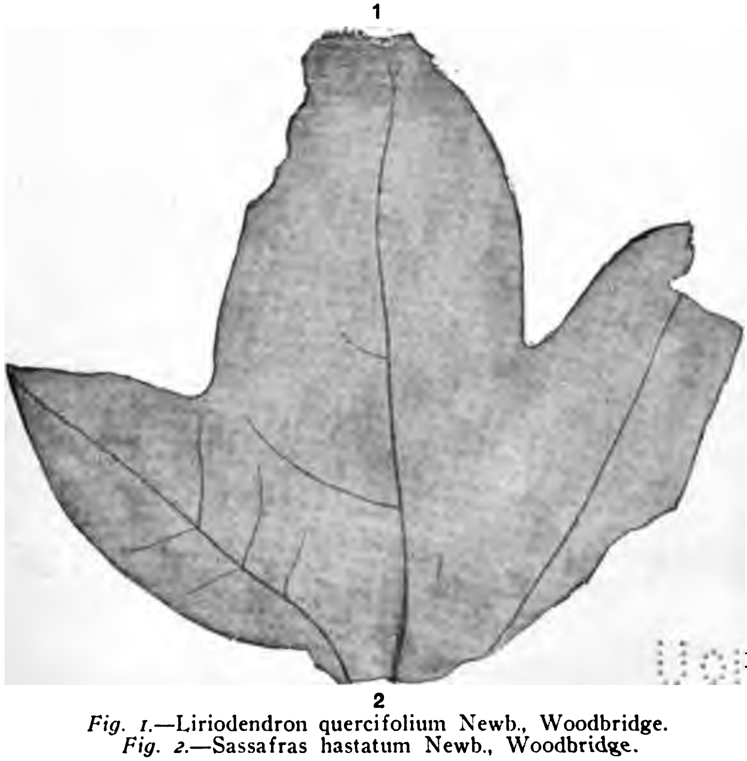

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Fig. 1.—Liriodendron quercifolium Newb., Woodbridge.
Fig. 2.—Sassafras hastatum Newb., Woodbridge.

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Fig. 1.—Sassafras progenitor Newb., Woodbridge.

Fig. 2.—Sassafras acutilobum Lesq., Woodbridge.

Fig. 3.—Menispermites Wardianus Hollick, locality unknown.

Fig. 4.—Menispermites borealis Heer (?) Woodbridge.

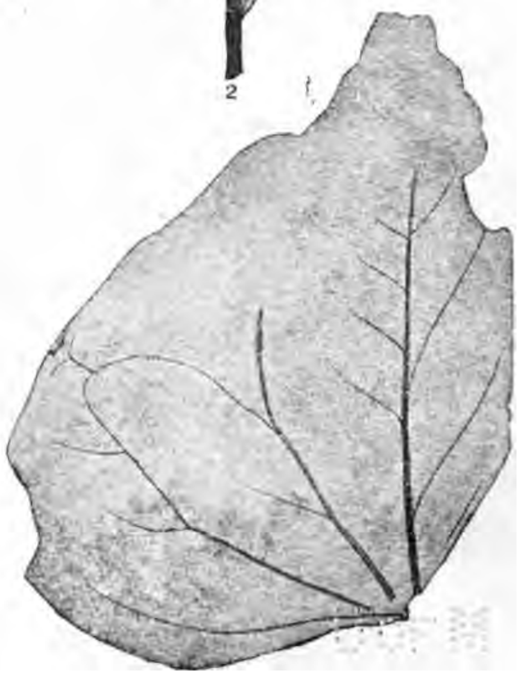

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PLATE XIX.

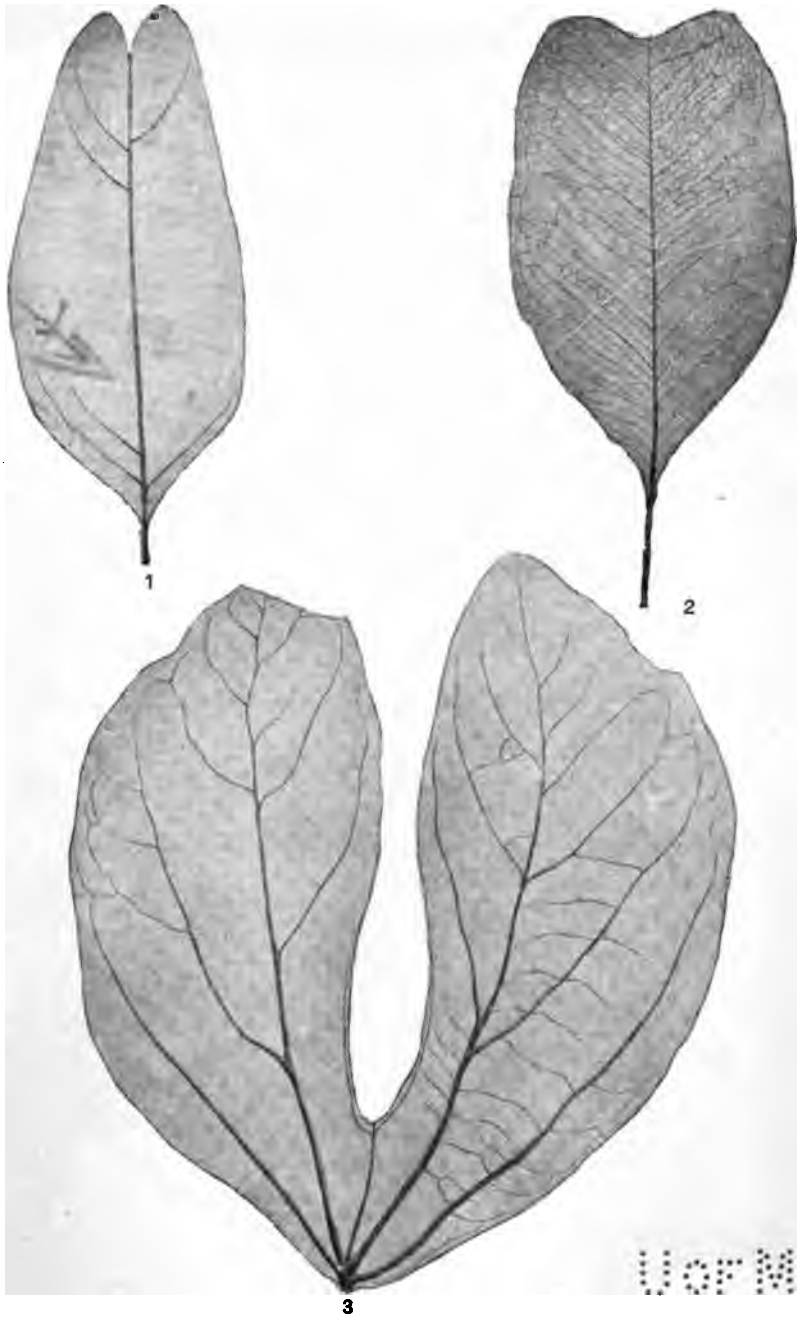

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Fig. 1.—Liriodendropsis retusa (Heer) Hollick, Woodbridge.
Fig. 2.—Liriodendropsis simplex (Newb.) Newb., Woodbridge.
Fig. 3.—Bauhinia cretacea Newb., Woodbridge.

PLATE XX.

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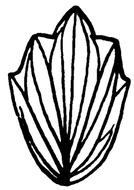

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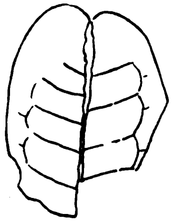

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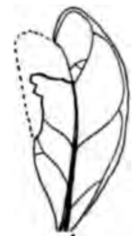

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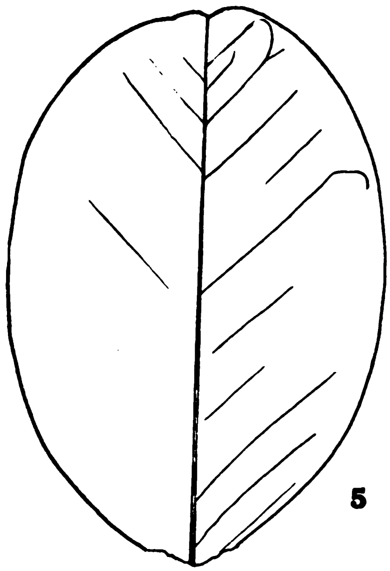

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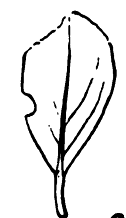

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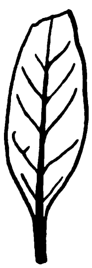

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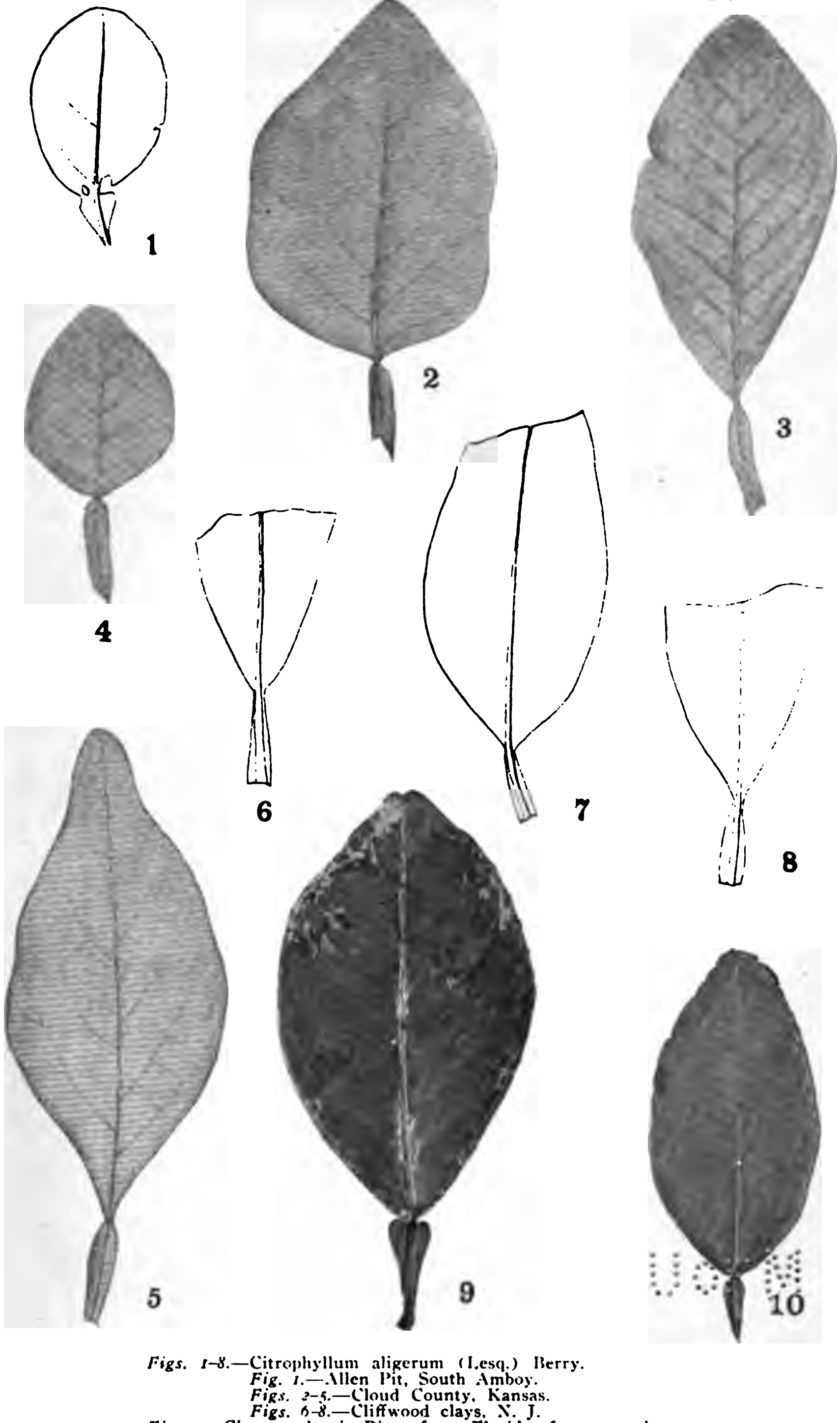
Figs. 1, 2.—Phyllites trapaformis Berry.
Fig. 1.—Type natural size, South Amboy.
Fig. 2.—Same enlarged four times.
Fig. 3.—Cæsalpinia raritanensis Berry, South Amboy.
Fig. 4.—Colutea primordialis Heer, South Amboy.
Fig. 5.—Leguminosites raritanensis Berry, South Amboy.
Fig. 6.—Persoonia Lesquereuxii Knowlton, South Amboy.
Fig. 7.—Andromeda novæ-cæsareæ Hollick, South Amboy.
Fig. 8.—Aralia quinquepartita Lesq., Hylton Pits.

PLATE XXI.



Figs. 1–8.—Citrophyllum aligerum (Lesq.) Berry.
Fig. 1.—Allen Pit, South Amboy.
Figs. 2–5.—Cloud County, Kansas.
Figs. 6–8.—Cliffwood clays, N. J.
Fig. 9.—Citrus vulgaris Risso from Florida, for comparison.
Fig. 10.—Citrus Limonum Risso from St. Croix, for comparison.

PLATE XXII.

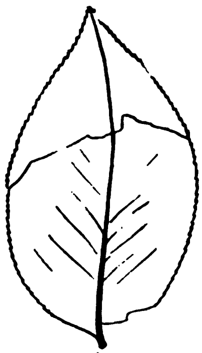


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Fig. 1.—Prunus (?) acutifolia Newb., South Amboy. *Fig. 2.*—Phaseolites manhassettensis Hollick, Milltown. *Fig. 3.*—Celastrophyllum minus Hollick, Milltown. *Fig. 4.*—Celastrophyllum spatulatum Newb., South Amboy. *Figs. 5–7.*—Celastrophyllum Newberryanum Hollick, South Amboy. *Fig. 8.*—Celastrophyllum decurrens Lesq., Woodbridge. *Fig. 9.*—Celastrophyllum crenatum Heer, South Amboy.

PLATE XXIII.

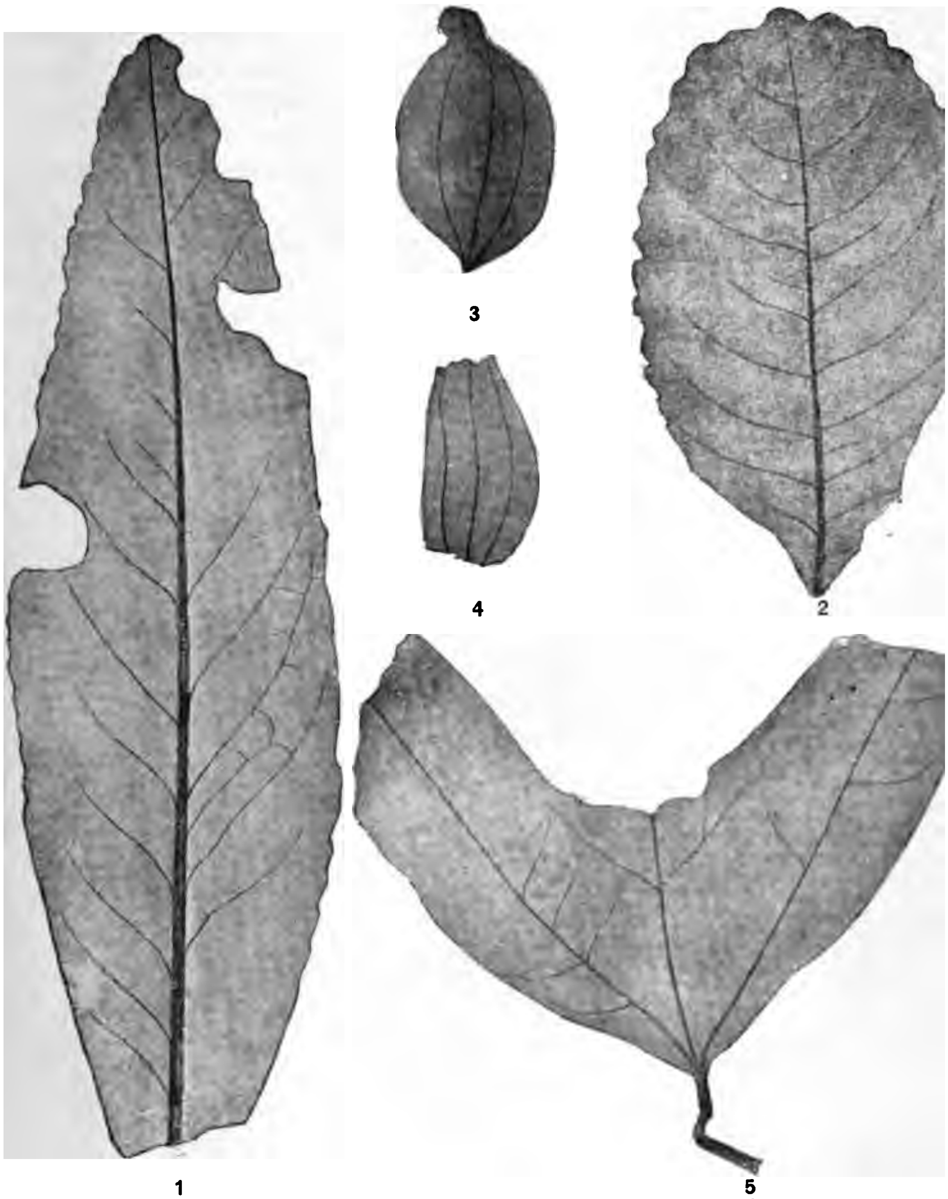


Fig. 1.—Celastrophyllum grandifolium Newb., locality unknown.
Fig. 2.—Celastrophyllum crenatum Heer, South Amboy.
Figs. 3-4.—Smilax raritanensis Berry, locality unknown.
Fig. 5.—Passiflora antiqua Newb., Woodbridge.

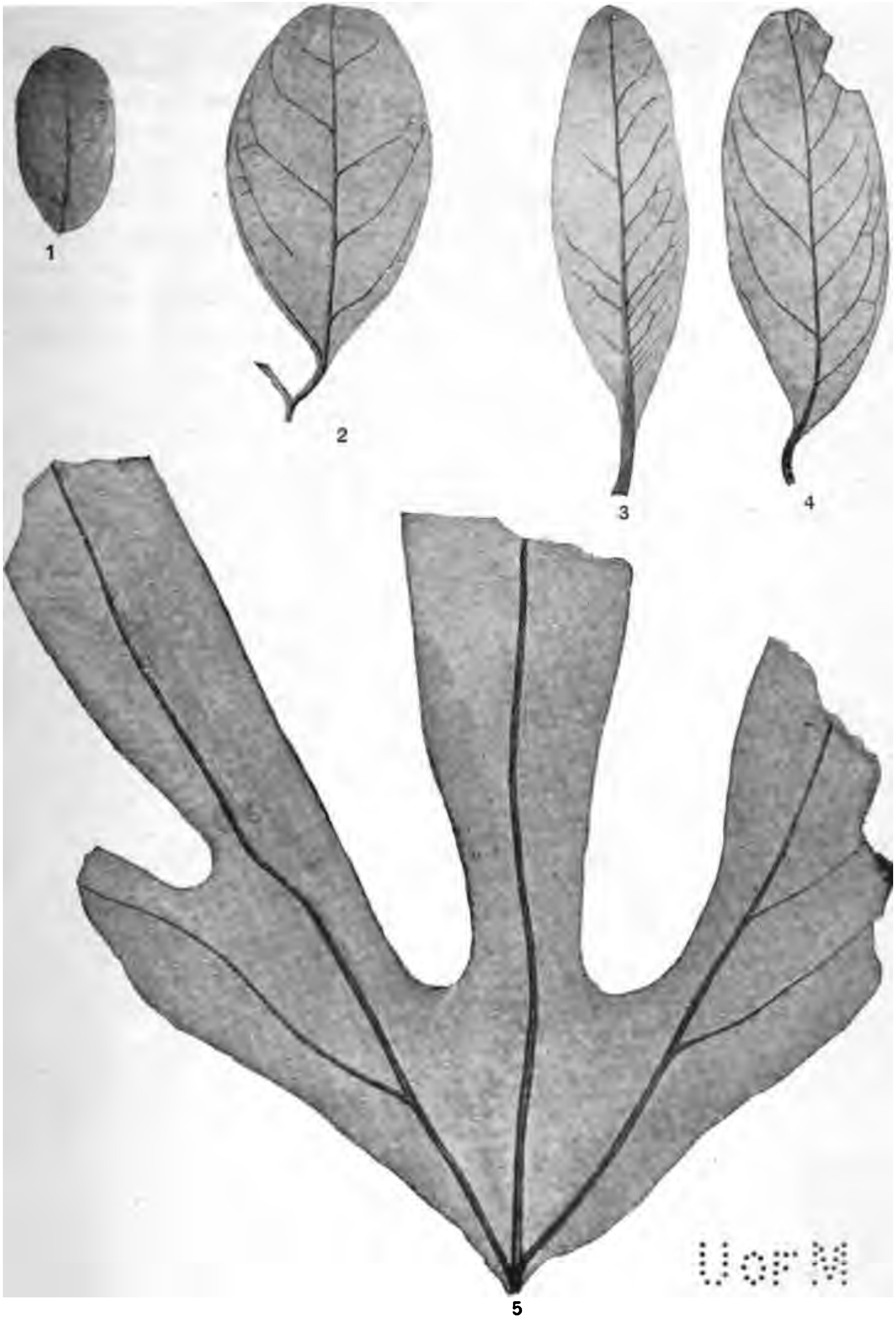
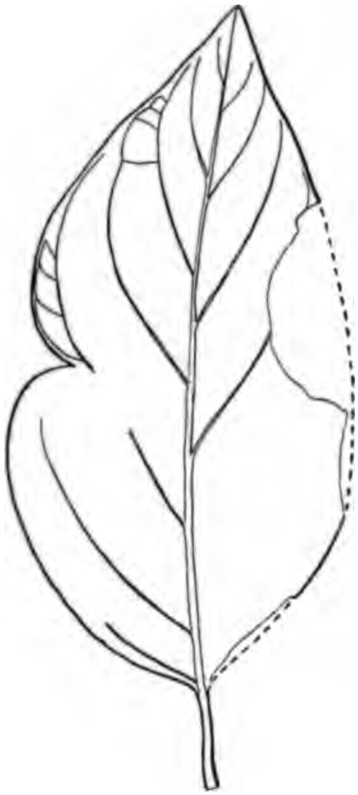


Fig. 1.—Myrsine oblongata Hollick, South Amboy (?).
Fig. 2.—Myrsine borealis Heer, South Amboy.
Figs. 3, 4.—Myrsine Gaudini (Lesq.) Berry, South Amboy.
Fig. 5.—Aralia quinquepartita Lesq., Woodbridge.

PLATE XXV.

Figs. 1–5.—Celastrus arctica Heer, South Amboy. *Fig. 6.*—Andromeda novæ-cæsareæ Hollick, South Amboy. *Fig. 7.*—Aralia Wellingtoniana Lesq., Woodbridge. *Fig. 8.*—Tricalycites papyraceus Newb., Woodbridge.

PLATE XXVI.



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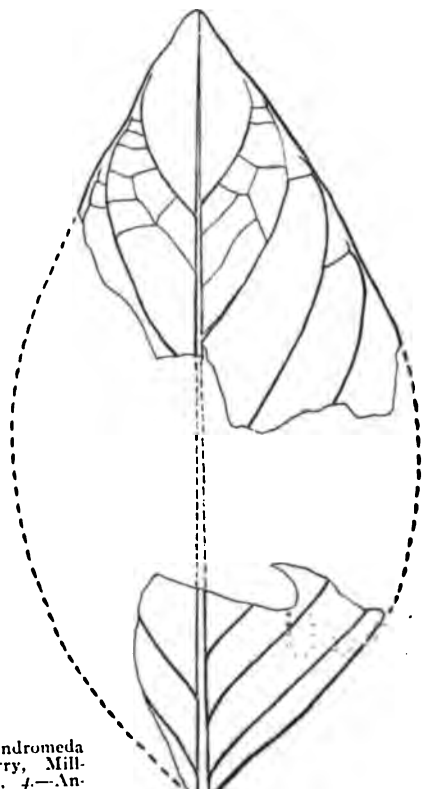

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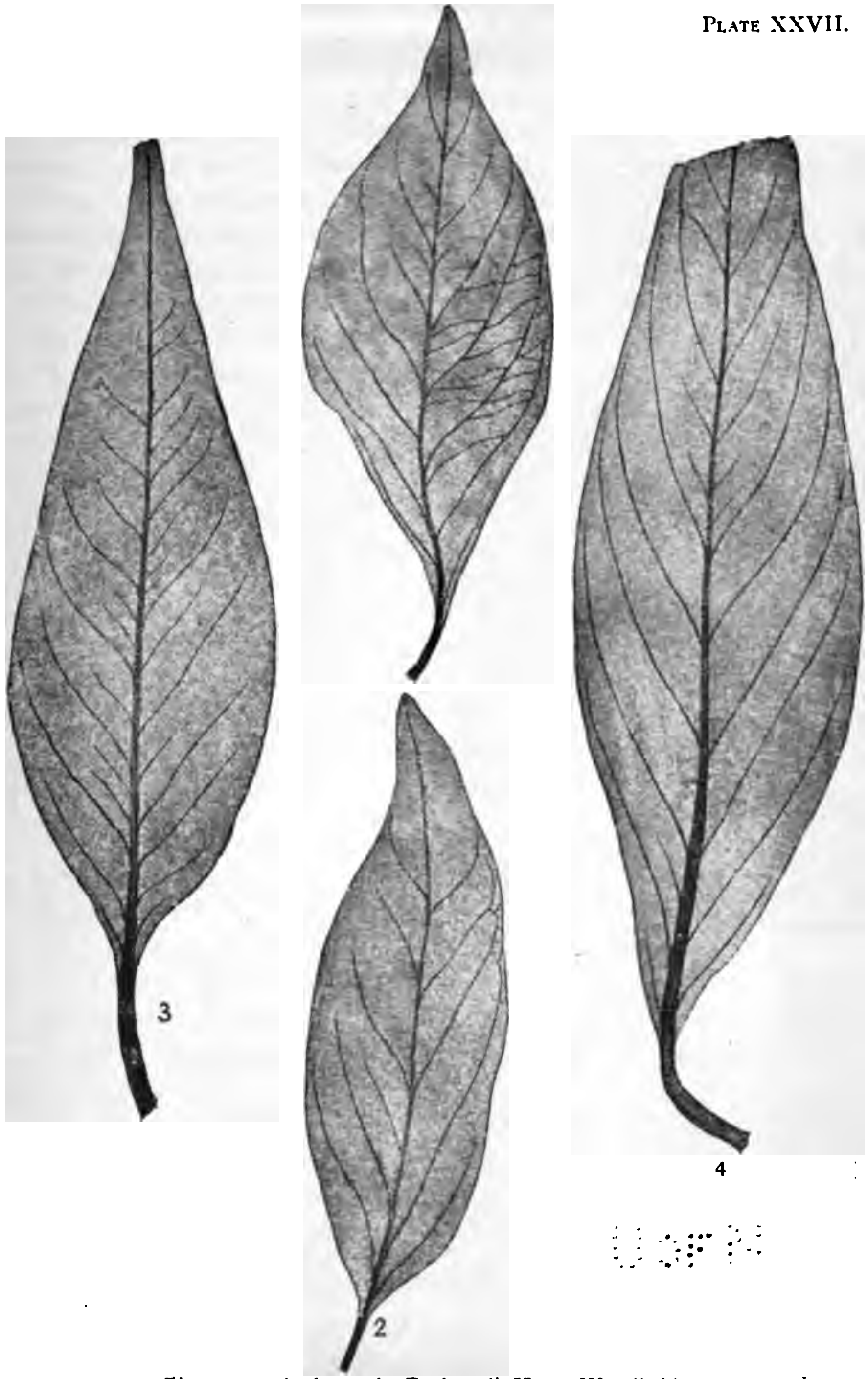
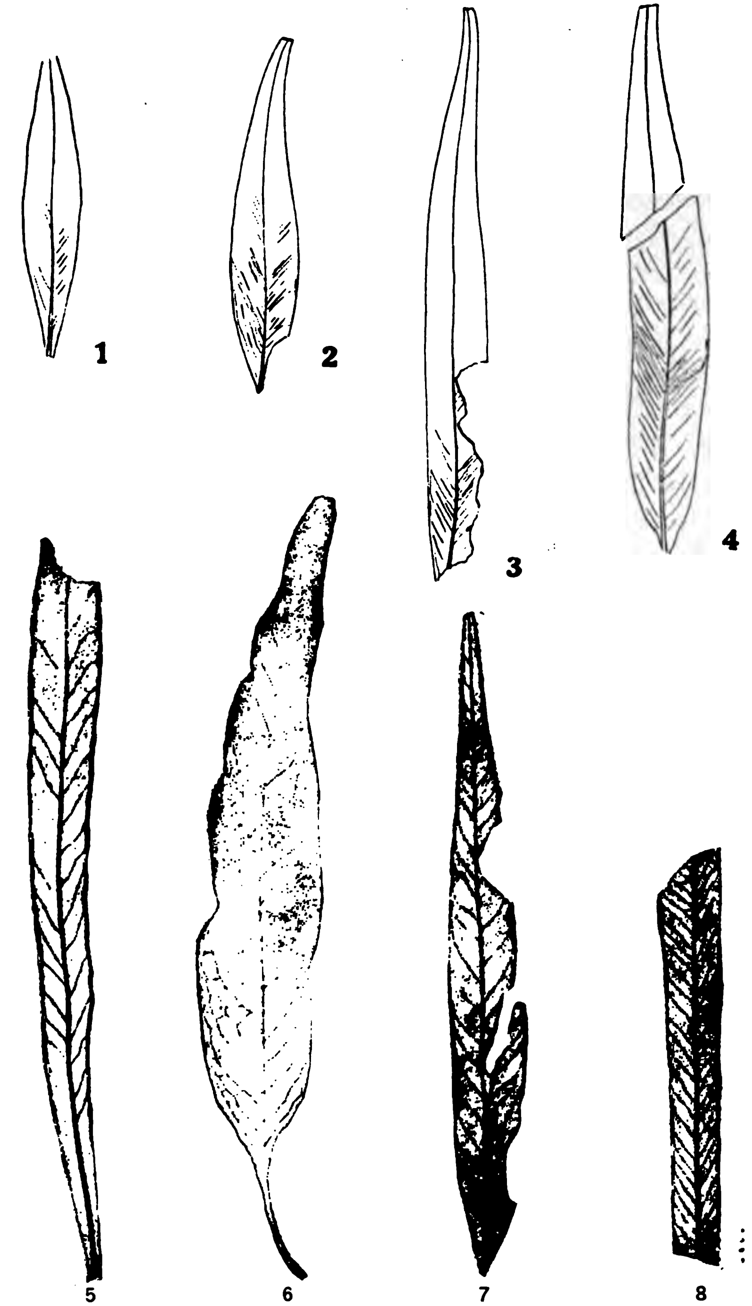
Figs. 1, 2.—Andromeda grandifolia Berry, Milltown. *Figs. 3, 4.*—Andromeda Cookii Berry, Woodbridge.

PLATE XXVII.



Figs. 1–4.—Andromeda Parlatorii Heer, Woodbridge.

PLATE XXVIII.



Figs. 1–4.—Eucalyptus angusta Velen., South Amboy.
Fig. 5.—Eucalyptus angustifolia Newb., South Amboy.
Fig. 6.—Eucalyptus attenuata Newb., South Amboy.
Fig. 7.—Eucalyptus Geinitzi (Heer) Heer, Woodbridge.
Fig. 8.—Eucalyptus linearifolia Berry, South Amboy.

Fig. 1.—Diospyros primæva Heer, South Amboy.
Figs. 2–4.—Calycites diospyriformis Newb., Woodbridge.
Fig. 5.—Diospyros elliptica (Newb.) Berry, Woodbridge.

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 4.

A Description of the Fossil Fish Remains

OF THE

Cretaceous, Eocene and Miocene Formations of New Jersey

By HENRY W. FOWLER

of the Academy of Natural Sciences of Philadelphia

With a Chapter on the Geology by

HENRY B. KÜMMEL

TRENTON, N. J.

MacCrellish & Quigley, State Printers, Opposite Post Office.

1911.

Letter of Transmittal.

TRENTON, N. J., MARCH 17, 1911.

The State Printing Board,
Trenton, N. J.

GENTLEMEN—Chapter 46, Laws of 1910, provides that in addition to an annual administrative report, the State Geologist shall prepare or cause to be prepared such scientific reports as are pertinent to the work of his department, and that the State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed such scientific reports.

The Board of Managers of the Survey, on December 6, 1910, adopted the following motion: That the publication of reports on the Plant Remains of the Cretaceous Clay Beds, and on the Fossil Fishes of the Cretaceous and Miocene Formations of South Jersey, already prepared or in process of preparation under the direction of the State Geologist, be recommended for printing to the State Printing Board, as provided in Chapter 46, Laws of 1910.

In accordance with the above, I request that the State Printing Board order printed 1,500 copies each of the two reports above mentioned, 100 to be bound, the balance in stiff covers sewed, as provided in the specifications for printing the Geological Survey reports.

Respectfully submitted,

HENRY B. KÜMMEL,
State Geologist.

STATE OF NEW JERSEY,
OFFICE OF COMPTROLLER OF THE TREASURY.
TRENTON, MARCH 20, 1911.

Henry B. Kümmel, Esq.,
State Geologist,
Trenton, N. J.

DEAR SIR—Your communication of the 17th inst., addressed to the State Printing Board, was laid before the Board at its meeting held on Friday, last, and, on motion, it was ordered that the publications referred to in your letter be printed and bound as requested. The work will be done by MacCrellish & Quigley, who were awarded the contract last fall.

Very respectfully,
E. J. EDWARDS,
Comptroller, as Secretary, State Printing Board.

INTRODUCTION.

The present work is intended simply as a descriptive summary of the fish remains known from the late Mesozoic and Cenozoic formations within the limits of the State of New Jersey. A full account of the stratigraphic paleontology of the Cretaceous is given by Dr. Stuart Weller, in his account of these formations, published in volume IV of the Paleontology series of the Geological Survey in 1907. Though no new collections have been made it is hoped that an exposition of the older ones, many of which have not been studied before, will be of value. The one great disadvantage is, as may have been expected, the lack of definite stratigraphic position for each species, the original data usually being incomplete or meager. This was due to the earlier collectors not attaching sufficient importance to preserving exact horizons and localities with their specimens. In many cases Dr. H. B. Kümmel, through his familiarity with the local geology, has been able to indicate the horizon from which the specimens came, and all such references to the present classification in the text are on his authority. To avoid confusion such references are inclosed in brackets with the initial K. In some cases comparison with other material in the collection of the Academy has greatly facilitated determinations, especially in the case of types or authoritatively determined material. I have attempted to illustrate as well as describe each species, wherever possible, from specimens, though in some cases have been obliged to use the original accounts. This is especially true among the chimæroids, where I have also allowed reproductions from Dr. Louis Hussakof's photographs. The general scheme of classification is that of Dr. David Starr Jordan, sometimes freely used or modified to suit present purposes.

Dr. O. P. Hay's Catalogue of Fossil Vertebrata of North America, and Dr. A. S. Woodward's Catalogue of Fossil Fishes in the British Museum, have been freely consulted with respect

to the diagnoses of the higher groups and generic synonymy. The writer is indebted to the Academy of Natural Sciences of Philadelphia, for the use of its library and collections, where most of this work was carried on. I am also under obligations to Dr. Henry B. Kümmel, the State Geologist, for the opportunity of consulting the collections of the State Geological Survey. All the figures are natural size, unless otherwise stated, in which case the reduction is shown by a line which indicates an inch. The material from the Geological Survey collections is indicated in the explanation by a *.

THE CRETACEOUS AND TERTIARY FORMATIONS OF NEW JERSEY.

H. B. KÜMMEL.

THE CRETACEOUS SYSTEM.

The Cretaceous strata of New Jersey outcrop southeast of a line from Trenton to New Brunswick, and as shown by well borings underlie all of South Jersey, although over most of the area they are deeply buried beneath later formations of Tertiary age and even along their belt of outcrop they are frequently covered with a mantle of sand and gravel of Quaternary age.

They comprise unconsolidated sands and clays, which dip 50 to 25 feet per mile to the southeast, and which have an aggregate thickness of from 500 to 1,000 feet, the greater thickness being found in the northern portion of the area. The lowermost beds are referred to the upper part of the Lower Cretaceous and are of non-marine origin. The middle and upper portions, however, belong to the Upper Cretaceous and contain an abundant marine fauna.

Raritan formation.—The Raritan formation is extremely variable, consisting chiefly of light-colored sands and clays, some of the latter being highly refractory. There is on the whole a preponderance of clays in the lower, and of sands in the upper, half of the series. Since it was laid down on an irregular surface its thickness is variable, ranging from 150 to 250 feet at the outcrop, but increasing to the southeastward, as shown by well-borings, to over 500 feet. Northeast of Trenton it rests unconformably upon the beveled Triassic shales, but farther southward upon the ancient crystallines of early Paleozoic or pre-Paleozoic age, and perhaps at undetermined points still farther south on earlier Cretaceous beds. It dips 40 to 50 feet per mile to the

southeast, the basal beds having the steeper inclination. The known fauna is very limited, consisting of a few pelecypods, some of which are blackish-water types, while two are typically marine, a plesiosaurian bone, and possibly an insect. Its flora embraces a wide range of genera and species, especially of dicotyledons, many of which are closely related to modern forms. It has been regarded by Ward as late Lower Cretaceous, and, therefore, approximately equivalent to the Gault of England and the Albian of continental Europe.[1]. Berry, however, has recently presented the paleobotanical evidence for its Cenomanian age.[2]

Magothy formation.—The lignitic sands and clays referred to the Magothy formation, and regarded as the lowermost of the Upper Cretaceous formations, were until recently included in the Raritan. On the shores of Raritan Bay they attain a thickness of about 50 feet, but diminish to the southwest and along Delaware River are only 25 or 30 feet. They are slightly glauconitic near the top. The Magothy rests unconformably on the Raritan, but the discordance is not great and indicates only a slight epeirogenic movement. A marine fauna of 43 species, possessing close affinities to that of the Ripley beds of the south and to the Senonian of Europe, is found on the shores of Raritan Bay, but farther southwest the deposits are apparently estuarine. The flora is abundant and presents a much more recent aspect than that of the Raritan. It is regarded by paleobotanists as showing upper Cenomanian affinities.

Merchantville clay.—The Merchantville is a black, glauconitic, micaeous clay, usually greasy in appearance and mas-

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[1] In continental Europe the Cretaceous system is divided as follows:

Upper Cretaceous	Danian Senonian Turonian Cenomanian
Unconformity	
Lower Cretaceous	Albian Optian Barremian Neoconian.

[2] Berry, E. W., Bulletin No. 3, p. 20 *et seq.*, Geological Survey of New Jersey.

sive in structure, weathering to an indurated brown earth. Its thickness is about 60 feet. It is conformable to the Magothy formation below and the Woodbury clay above. Its invertebrate fauna is large and varied, and although it contains many forms common to the beds above and below, its most characteristic species are conspicuous for their absence or great rarity in the adjoining strata. The Merchantville clay represents the lower part of the Crosswicks clay of Clark, forms the base of the Clay-marl series of Cook, and is the lowest of the five formations in New Jersey which are correlated with the Matawan formation of Maryland.

Woodbury clay.—The Woodbury is a black, non-glauconitic, jointed clay about 50 feet thick, which weathers to a light chocolate color, and when dry breaks into innumerable blocks, frequently with a conchoidal fracture. Its invertebrate fauna of 95 marine species is more closely allied to that of the Magothy than to the subjacent Merchantville. It is conformable both with the Merchantville below and the Englishtown sand above. It is the upper part of the Crosswick clay of Clark, and forms part of the Clay-marl series of Cook. It is also one of the formations correlated with the Matawan of Maryland.

Englishtown sand.—The Englishtown is a conspicuous bed of white or yellow quartz sand slightly micaceous and sparingly glauconitic. Locally it contains thin laminae of fine brittle clay. So far as known it contains no fossils. It decreases in thickness from 100 feet near Atlantic Highlands to less than 20 feet in the southern portion of the State. It represents the lower part of the Hazlett sand of Clark, and forms a part of Cook's Clay-marl series. It was formerly called the Columbus sand and is the equivalent of a part of the Matawan formation.

Marshalltown clay-marl.—The Marshalltown ranges from a black sandy clay to an argillaceous greensand marl. Locally it is abundantly fossiliferous, its characteristic invertebrate species being in part recurrent forms from the Merchantville, and in part a new element, which recurs again in a higher formation. although absent or inconspicuous in the immediately succeeding beds. Its thickness is 30 to 35 feet. It is a portion of the "laminated" sands which formed the upper part of the Clay marl

series of Cook, although in the southwestern protion of the State he referred these beds to the Navesink (Lower) marl. It was included in Clark's Hazlett sands, a sub-division of his Matawan.

The Wenonah and Mount Laurel sands.—Above the Marshalltown clay-marl there is a considerable thickness of sand regarding which there has been some difference of opinion. The terms Wenonah and Mount Laurel have both been applied to it in whole or in part. Lithologically these sand layers are not sharply differentiated from each other, although the lower part (Wenonah) is generally a fine micaceous sand and the upper part (Mount Laurel) is coarser and contains considerable greensand. Paleontologically, however, they are quite distinct. The Wenonah fauna is largely recurrent from the Woodbury, with comparatively few prominent species common either to the Marshalltown below or the Mount Laurel and Navesink above. The same elements are prominent again still higher in the Red Bank. The Mount Laurel invertebrate fauna is identical with that of the Navesink above, and is closely allied to the Marshalltown, but contains a foreign element, chief among which is the cephalopod *Belemnitella americana* and the brachiopod *Terebratella plicata*, so that the indistinct lithological line between the Wenonah sand and Mount Laurel sand is of considerable paleontological significance. The combined thickness of these formations is 40 to 80 feet, the Mount Laurel being limited to a very thin bed at Atlantic Highlands (Cook's sand-marl) but increasing much in thickness toward the southwest. The Wenonah sand is the highest bed correlated with the Matawan of Maryland, while the Mount Laurel is the base of the Monmouth.

Navesink marl.—The Navesink marl consists of greensand marl, mixed with varying amounts of quartz sand and fine earth, the latter of which contains much carbonate of lime in a powdery state. Where purest the marl has a dark-green or bluish-black color. The upper part of the bed contains progressively less greensand and is more clayey. The invertebrate fauna is large (121 species, Weller), and is allied with that of the Marshalltown and Merchantville beds, while the characteristic forms of

the Magothy, Woodbury and Wenonah are absent. The formation has a maximum thickness of about 40 feet, diminishing southward to 25 feet or less. It corresponds in general to Cook's Lower Marl, although locally beds referred by him to the Lower Marl have proved to be the Marshalltown. It rests conformably upon the beds below and grades upward into the Red Bank sand, or where that is absent into the Hornerstown marl.

Red Bank sand.—The Red Bank sand is for the most part a fairly coarse ferruginous yellow and reddish-brown quartz sand, locally indurated by the infiltration of iron. The lower beds are in many places somewhat clayey. The Red Bank invertebrate fauna has come chiefly from these clayey layers. In its essential features it is a recurrence of the *Lucina cretacea* fauna of the Magothy, Woodbury and Wenonah formations, and differs in important respects from the Navesink fauna immediately below. It occurs only in the northern part of the coastal plain, where its maximum thickness is 100 feet, but it thins out and disappears midway across the State. It is the Red Sand of Cook and earlier writers, but does not include certain sands in the southern portion which were correlated by him with the Red Sand of Monmouth county, but which in reality are referable to the Wenonah-Mt. Laurel horizon. With the overlying Tinton bed, it is the uppermost of the beds correlated with the Monmouth formation of Maryland.

Tinton bed.—A lense of green indurated clayey and sandy marl, having a thickness of from 10 to 20 feet, overlies the Red Bank sand in Monmouth County. Its invertebrate fauna is more closely allied to that of the Navesink than of the Red Bank and is characterized by large numbers of crustacean claws of the genus Callianassa. It is Cook's "indurated green earth," regarded by him and other writers as a part of the Red Sand, but in view of its faunal and lithologic differences it deserves some separate recognition.

Correlation of the Magothy-Tinton beds.—The assemblage of fossils making up the invertebrate faunas of the beds from the Magothy to the Tinton inclusive constitute a larger faunal unit, much more sharply separated from the faunas above and below

than are any of its constituent faunules from each other. Weller has shown that this larger faunal unit is made up of two or more distinct facies, one of which, the Cucullaea fauna, is characteristic of the more glauconitic beds; namely, the Merchantville, Marshalltown, Navesink and Tinton, while the other facies characterized by *Lucina cretacea* or its associates occurs in the clays or clayey sands of the Cliffwood, Woodbury, Wenonah and Red Bank formations. The two facies existed contemporaneously and migrated backward and forward across the present outcrop of these beds in New Jersey as deeper or shallower water conditions prevailed. The larger faunal unit is closely related to the Ripley fauna of Alabama, Mississippi and Texas. On faunal evidence all the formations from the Magothy to Tinton inclusive are referable to the Senonian of Europe, although on floral evidence the Magothy might be regarded as Cenomanian.

Hornerstown marl.—The Hornerstown marl is a bed of glauconite with clay and sand and not differing materially from the Navesink. Its fauna is meager, but is totally different in its essential characteristics from the faunas of all the underlying formations. *Terebratula harlani, Cucullaea vulgaris* and *Gryphaea dissimilaris* (Weller) are characteristic forms. A shell bed at the top of the formation is a conspicuous feature at many localities. The thickness is 30 feet or less. At the north it rests with apparent conformity on the Tinton; where that is absent it lies on the Red Bank, and farther south it is continuous with the Navesink, owing to the disappearance of the Red Bank. It is conformably overlain by the Vincentown except where overlapped by Miocene formations. It is the Middle Marl of Cook, the Sewell marl of Clark, and is a part of the Rancocas group.

Vincentown sand.—The Vincentown sand presents two phases, a calcareous or limesand, semi-indurated and largely a mass of broken bryozoan, echinoid, coral and other calcareous remains, and a glauconitic quartz-sand phase. The two phases occur in alternating layers, although the former is more common in the basal portion, particularly to the south, while the quartz-sand phase predominates in Monmouth County. The fauna of the limesand phase contains large numbers of bryozoa, echinoids and

foraminifera, while in the siliceous phase elements of the Hornerstown fauna occur in association with forms characteristic of the calcareous phase. Its thickness varies from 25 to 70 feet, but well-borings have shown that it thickens greatly down the dip. It rests conformably upon the Hornerstown marl and is overlain conformably by the Manasquan marl or overlapped by Miocene beds. It includes the "limesand" and "yellow sand" of Cook, the former of which was regarded by him as a part of the Middle Marl.

Manasquan marl.—The Manasquan marl in its lower portion (13-17) is composed chiefly of glauconite, but the upper part (8-12 feet) is made up of very fine sand mixed with greenish-white clay, piles of which look like heaps of ashes—hence the name "ash marl." The invertebrate fossils are not abundant and are poorly preserved, the commonest occurring also either in the Hornerstown or Vincentown. Its thickness is about 25 feet. It corresponds to the "green" and "ash" marls of Cook's Upper Marl bed and is the youngest of the Cretaceous formations exposed in New Jersey. It probably rests conformably upon the Vincentown and at most exposures is succeeded unconformably by Miocene or Pleistocene deposits, although locally it is overlain by a bluish marl of Eocene age without apparent unconformity.

Correlation of the Hornerstown, Vincentown and Manasquan.—The invertebrate faunas of these three formations are closely related and form a larger fauna sharply separated from the Ripleyian fauna of the underlying Magothy and Tinton beds. This fauna has not been recognized south of Maryland. It shows certain affinities with the lower or Maestrichtian division of the Danian series of Western Europe (Weller).

EOCENE SYSTEM.

Shark River marl.—Eocene deposits in New Jersey are limited in outcrop to small areas near Allenhurst (Deal), Shark River and Farmingdale, in Monmouth County, where a mixture of greensand and light-colored earth 11 feet in thickness and carrying Eocene fossils rests without apparent unconformity

upon the "ash" marl of the Manasquan. The conformity, however, is only apparent, well-borings indicating that the Shark River, as this formation has been called, probably overlaps the Cretaceous. Clark[1] considers that it is not possible to correlate the Shark River marl with any other known Eocene deposits and regards them as probably older than the Eocene of Maryland. By some other authors, however, they have been placed above the Maryland Eocene.

MIOCENE SYSTEM.

Beds of known Miocene age are widely distributed in the coastal-plain portion of New Jersey, where they overlap the Eocene and many of the Cretaceous formations. At the north they rest on beds ranging from the Eocene to the Hornerstown marl, while in the southern portion outliers are found upon the Mount Laurel sand.

Kirkwood formation.—Under the term Kirkwood have been included all beds of demonstrable Miocene age which outcrop in New Jersey. These beds vary lithologically in different regions, but they are predominantly fine micaceous quartz sands often delicately banded in shades of salmon-pink and yellow. Black, lignitic clays occur in many localities at or near the base. In the southern portion (Salem and the adjoining portion of Cumberland County) a thick (80-90 feet) bed of chocolate or drab-colored clay occurs, above which there are (or were formerly) exposures of a fine clayey sand containing great numbers of shells (the Shiloh marl of many reports), which, in the localities where it occurs, forms the upper bed of the Kirkwood. The thickness is about 100 feet or more along the outcrop. On the basis of the abundant invertebrate fauna in the beds at Shiloh, the Kirkwood is believed to correspond in a general way with the Calvert formation of Maryland, the lowest division of the Chesapeake group.

Well-borings at Atlantic City, Wildwood and other points along the coast have demonstrated the presence there of a great thickness of Miocene strata not apparently represented in outcrop.

[1] Report of the State Geologist of New Jersey for 1893, p. 346.

At Atlantic City clays, sands and marls from 390 to 1,225 feet below tide carry Miocene fossils, and at Wildwood those from 300 feet to 1,090 feet and perhaps to 1,244 are Miocene. From the fossils it is evident that strata referable to the St. Marys, Choptank and Calvert horizons of the Chesapeake group are present.

Cohansey sand.—Overlying the Kirkwood at its outcrop is a formation composed chiefly of quartz sand, locally with laminae and lenses of light-colored clay and occasional lenses of gravel. This formation outcrops over a wider area of the coastal plain than any of those heretofore discussed. Obscure casts of molluscan shells have been found in it, but these are of no value in determining its age. Plant remains from near Bridgeton indicate a flora comparable with that of certain European upper Miocene localities. It dips southeastward 9 or 10 feet per mile, and overlies the Kirkwood with seeming unconformity.

Inasmuch as sands and clays similar to the Cohansey are revealed in borings along the coast and there overlie clays carrying Miocene fossils characteristic of the St. Marys, the highest division of the Chesapeake group, the Cohansey apparently belongs to a still later stage of the Miocene or perhaps even to the Pliocene. It is possible, however, that as now defined it may represent in part at least the shoreward phases of the fossiliferous Miocene clays found in the borings along the coast, and that it should be correlated with the Choptank and St. Marys of Maryland. In the light of all data at present available, however, the former view seems most probably the true one.

PLIOCENE SYSTEM.

Beacon Hill formation.—Under the term Beacon Hill there were described certain beds of gravel and sand occurring as outliers on the higher hills of Monmouth County. Later the sand beds were correlated with the great body of sand now included in the Cohansey formation, leaving only the gravel in the Beacon Hill formation. It is chiefly quartz, but contains much chert and some hard sandstone and quartzite. The chert pebbles are uniformly much decayed and are frequently very

soft. The quartz and quartzites are often more or less corroded. The formation occurs as isolated remnants on some of the highest hills of the coastal plain. It is perhaps to be correlated with the Lafayette formation farther south.

CORRELATION OF LOCALITIES FURNISHING FISH REMAINS.

The fossils described in this report so far as any definite localities are given were obtained from comparatively few points. The same names recur again and again. Long Branch, Deal, Poplar, Shark River, Farmingdale, Hornerstown, Crosswicks, Pemberton, Birmingham, Vincentown, Blackwoodstown, Barnsboro, Mullica Hill, Allowaystown, Shiloh, and Stow Creek are frequently mentioned. At some of these localities the geological formation can be identified with certainty, while at others several formations outcrop in the pits from which the specimens probably were obtained so that there is some element of doubt. The following paragraphs indicate the possibilities at each locality.

Long Branch.—The Hornerstown marl outcrops north of Long Branch and at an early day was dug at several points. South of that place it is covered by the Vincentown sand (Cook's yellow sand), but was reached in pits at a few localities. Specimens labelled Long Branch are assumed to come from the Hornerstown marl.

Deal and Poplar.—The numerous marl pits along Poplar Brook near Poplar and Deal are in the Manasquan marl—the green marl and ash marl of Cook's Upper Marl. South of Deal, however, near the head of the north arm of Deal Lake the Shark River (Eocene) marl is found. It seems to be safe to conclude that specimens from Poplar are to be regarded as from the Manasquan marl, while those from Deal may be either from the Manasquan marl or the Shark River marl with chances perhaps favoring the former since the pits in the Manasquan were more numerous than those in the Shark River.

Shark River.—Eocene beds—the Shark River marl—are exposed in pits along Shark River above the village of that name. Some of these pits penetrated also the Manasquan marl, while

locally a dark astringent clay of Miocene age overlies the Shark River marl. Under these circumstances there is some uncertainty as to the formations from which the fossils came. Inasmuch, however, as the Shark River marl was better exposed here than elsewhere in the State most of the species are probably referable to this horizon, unless there is specific evidence to the contrary.

Farmingdale and Squankum.—Immediately north of Farmingdale in a large pit along the railroad there is an extensive exposure of the Manasquan marl overlain by a dark clay of Miocene age. Southwest of the village along Manasquan River is a line of openings mostly in the Manasquan marl, overlain by Miocene or Pleistocene deposits, but, as stated by Cook, two of them in the "blue and ash marls," *i. e.*, the Shark River and upper part of the Manasquan marl. Whitfield[1] cites numerous Eocene invertebrate forms "in the upper layers of the Upper Green marls at Shark River, Farmingdale and Squankum, New Jersey," so that it seems to be well established that Eocene fossils have been collected from Farmingdale and Squankum, although the Manasquan marl is the one most commonly exposed. In this report specimens labelled simply "from Farmingdale," "from Squankum" are tentatively referred to the Manasquan marl, although it is recognized that they may be from the Shark River formation. In the case of others there is no doubt since their labels expressly state "from the Eocene marl at Farmingdale," etc. The Miocene clay also may have yielded some forms.

Hornerstown.—Of the specimens herein described from Hornerstown it is probably safe to refer them all to the Hornerstown marl bed (Cook's Middle Marl), since that layer was extensively opened for marl at various points near Hornerstown during the years when these collections were made. However, the Red Bank sand occurs along the creek west of the village beneath which at a slightly lower level the Navesink marl is found. It is possible, therefore, that some material was ob-

[1] Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. Geol. Survey of N. J., Paleontology, Vol. II; also U. S. G. S. Monographs XVIII, 1891.

tained from one or the other of the lower formations and not from the Hornerstown marl.

Crosswicks.—Some material has been reported from "Crosswicks." If it was obtained near the village of that name it is referable to either the Woodbury clay or the Merchantville clay, both of which formations occur near that place, the former being the better exposed. Neither of these is a marl, although the Merchantville is generally a marly clay. If, on the other hand, the locality should be Crosswicks Creek, the specimens may have come from any one of half a dozen horizons, as all the formations from the Merchantville to Vincentown are well exposed along the creek between Crosswicks and New Egypt. Since, however, the Navesink marl (Cook's Lower Marl) was the only one actively exploited in those days, the chances are that they came from it, if the locality reference is to the creek. In the suggested correlations it has been assumed that the specimens came from the village and they are referred to the Woodbury or Merchantville clays, but with more or less doubt.

Birmingham.—At Birmingham there are extensive marl pits formerly worked by the Pemberton Marl Company. A few miles northeast of this point the Red Bank sand which separates the Navesink from the Hornerstown marl, disappears and the two marl beds are combined. It is the combined bed which was so extensively worked at Birmingham, and the specimens are referred to the Navesink–Hornerstown marl.

Pemberton.—The village of Pemberton lies a scant two miles east of Birmingham. Many of the fossils whose locality is cited as Pemberton, unquestionably came from the pits of the Pemberton Marl Company, as is shown by the donor, J. C. Gaskill, who was superintendent of the pits, and they are, therefore, referable to the Navesink–Hornerstown marl. At Pemberton, itself, the Manasquan marl is exposed in the creek banks and was formerly dug at numerous points above the village. Hence some of the material labelled Pemberton may be from the Manasquan formation. The outcrop of Vincentown sand lies between Birmingham and Pemberton, so that the possibility of some material coming from this horizon must not be overlooked.

Vincentown.—Below Vincentown the limesand (Vincentown sand) and Navesink–Hornerstown marl are exposed in a line of pits extending for two miles or more down stream to Eayrestown. At Vincentown and upstream for a mile or more the Manasquan marl was formerly dug. It seems best to refer to the Manasquan the specimens credited to Vincentown except where their occurrence in the limesand beds is expressly stated.

Blackwoodstown.—South of Blackwood are old pits in the Navesink-Hornerstown marl, which is here overlaid by the Vincentown limesand and that in turn by the Kirkwood (Miocene) sand. Specimens from "the greensand at Blackwoodstown" are clearly from the combined Navesink-Hornerstown bed. Other specimens may be from the Vincentown or the Miocene.

Barnsboro.—There are no marl beds at Barnsboro, but in the valleys of several branches of Mantua creek from one to three miles east, south and west of the village, there are numerous exposures of the Navesink–Hornerstown marl and several old pits, once extensively worked. The material from "Barnesborough" probably came from these pits. The Vincentown limesand is found at some points in the vicinity and above that the Kirkwood sand, either of which horizons may have furnished some specimens.

Mullica Hill.—A prominent bluff within the village and just south of the creek at Mullica Hill has always been a favorite collecting ground. The conspicuous feature of the section is a "5-foot indurated shell bed, filled with fossils. The matrix in which the fossils are imbedded is sandy, with pea-like quartz pebbles, the whole colored dark green by a considerable percentage of glauconite. Above the shell bed is a nearly pure greensand marl, while beneath it there are exposed 20 feet or more of yellow or red quartz sand containing poorly preserved casts of *Belemnitella americana, Gryphæa* and *Neithea.*" This sand is the Mount Laurel sand, while the shell bed and overlying glauconite bed represent the Navesink marl and perhaps a portion of the Hornerstown marl, which, in this portion of the State, are not separated by any intervening horizon. Since the fossils collected at this exposure probably came chiefly from the shell

bed and lower portion of the marl they are unquestionably to be referred to the Navesink, or to the Navesink-Hornerstown marl.

In marl pits along the creek a mile or more above the village the upper portion of the Navesink–Hornerstown bed is exposed and above it the Vincentown limesand. These localities may have yielded some of the material credited to Mullica Hill. The Kirkwood sand is now exposed in a small bank in the southern limits of the village and overlies the Vincentown sand at the marl pits, and while the writer has never noted any fossils in it, the possibility of some Miocene forms being found in this locality must not be wholly overlooked.

Alloway and Riddleton.—A number of specimens are credited to "Allowaystown." No greensand marl beds are known nearer to Alloway than two and one-half miles northwest along the headwaters of Swede's Run. Here there are old pits in the Manasquan marl. Since these exposures are only a mile west of Riddleton, the material credited to that place may have come from them, but there is less certainty regarding that credited to Alloway. In the vicinity of the latter place there are numerous exposures of a dark, tough clay, sometimes called the Alloway clay,[1] known to be of Miocene age and now included in the Kirkwood formation. Possibly the material "from Allowaystown" may be Miocene and from this clay.

Shiloh, Jerico, Stow Creek.—Miocene fossils have been found in great abundance in the marl pits along the headwaters of Stow Creek near Shiloh and Jerico in Cumberland County. These beds have often been called the Shiloh marl and the specimens credited to Shiloh, Jerico and Stow Creek all came without question from these pits. These pits lie four and one-half to five miles southeast of Alloway and perhaps the material labeled Allowaystown is also from them. The Shiloh marl is regarded as a part of the Kirkwood formation.

Greensand No. 5, of New Jersey.—Many of the specimens are referred by Cope to "Greensand No. 5, of New Jersey," "Greensand No. 4, of N. J.," etc. From the localities cited it has been possible to identify "No. 5" as the Hornerstown marl, but I

[1] Report on Clay, Vol. VI., Final Report Series Geol. Surv. of New Jersey, 1904.

have not been able to find any certain explanation of these designations.

Whitfield[1] in discussing the paleontological horizons of the marl beds of New Jersey, speaks of "seven distinct horizons. six of which may be classed as Cretaceous and one as Eocene," which "conform very closely, if not exactly, to certain stratigraphical lines, which were long since established by the State Geologist * * *." These were 1) The Raritan clays; 2) The Camden clays at Fish House, containing 12 species of Unionidae; 3) The micaceous clays at Crosswicks Creek below the Lower Marl bed; 4) the Lower Marl bed; 5) the Middle Marl bed; 6) the Cretaceous portion of the Upper Marl bed (Manasquan marl), and 7) the Eocene portion of the Upper Marl (the Shark River). Possibly it is some such correlation as this that Cope had in mind. If so, his "Greensand No. 2" must be relegated to the Pleistocene as it is now known that the *Unionidæ* clays at Fish House are not Cretaceous but Pleistocene; Greensand No. 3 may include the Merchantville, Woodbury, Marshalltown clays and certain clayey layers in the Englishtown and Wenonah sands. Greensand No. 4 would correspond to the Navesink marl, but might also include certain phases of the Red Bank sand.

[1] Whitfield, loc. cit. p. 19, 20.

DESCRIPTION OF SPECIES.[1]

Class PISCES.

THE FISHES.

Cold-blooded aquatic vertebrates breathing by means of gills not purse-shaped, but attached to cartilaginous or bony gill-arches. Skull with lower jaw. Limbs developed as fins, rarely wanting. Body usually covered with scales, bony plates or horny appendages, sometimes naked. Median line of body with one or more fins composed of cartilaginous rays joined by membrane

The *Leptocardii* (Lancelets) and *Cyclostomes* (Lampreys), usually to be considered with all fish-like vertebrate faunas, are not known from any undoubted fossil remains, and comprise but a small number of existing forms. The opinions of many writers vary as to the value of the different sub-classes embraced in the present class, though most all agree as to the status of the lancelets and lampreys. I accept five, as the *Elasmobranchii, Holocephali, Dipnoi, Crossopterygia* and the *Actinopteri*. At the present time only the *Elasmobranchii* and *Actinopteri* are represented by existing types within the limits of New Jersey, though it is probable that some *Holocephali* may yet be found off our shores in deep water. The *Elasmobranchii* and *Holocephali* are, however, very abundant among the remains in our Cretaceous beds, and the former represent about half the entire number of fossil fishes known from that formation.

Sub-Class ELASMOBRANCHII.

SHARK-LIKE FISHES.

Teeth distinct. Jaws distinct from skull, joined to it by suspensory bones. Gill-openings five to seven slits on each side of pharynx. Membrane bones of head undeveloped, except some-

[1] By Henry W. Fowler.

times rudimentary opercle. Skeleton cartilaginous. Skull without sutures, mandibular suspensorium present. No air-vessel. Intestine with a spiral valve. Arterial bulb with three series of valves. Optic nerves united by a chiasma. Cerebral hemispheres united. Gills not free, attached to skin by outer margin. Ova few and large, impregnated and sometimes developed internally. Embryo with deciduous external gills. Tail hetorocercal. Ventral fins abdominal. Males with large intromittent organs or claspers attached to ventral fins. Skin naked or covered with minute rough scales, sometimes with spines.

An almost perfect gradation exists from the true sharks to the skates, though the notidanid sharks are somewhat removed from the former. The orders are the *Ichthyotomi, Notidani, Asterospondyli, Cyclospondyli, Rhinæ* and *Batoidei*. The first of these is entirely extinct, though no fossils have been found in New Jersey referable to this group.[1] All the others are represented by living forms, and possibly at least one of the *Notidani* may occur off our shores in deep water.

Order NOTIDANI.

THE NOTIDANOID SHARKS.

Vertebral column imperfectly segmented, each segment equivalent to 2 vertebræ and bearing 2 neural arches. Gill-openings 6 or 7. Dorsal fin 1. Anal present.

This order contains the most primitive of existing sharks. Families 2, recent and extinct.

Family HEXANCHIDÆ.

THE GRISETS.

Eyes anterior or submedian. No nictitating membrane. Teeth above, 1 or 2 pairs, awl-like, next 6 broader, and each with several cusps, 1 enlarged. Teeth below, 6 large comb-like

[1] I may note that a tooth of *Petalodus*, reported by Leidy, in Proc. Acad. Nat. Sci. Phila., 1876, p. 9. is doubtfully ascribed to the New Jersey Cretaceous and is therefore not likely admissible to that fauna.

laterally, besides small posterior. Gill slits 6 or 7. Spiracle small. Dorsal 1, no spine, opposite and like anal. No caudal pit. Viviparous.

Living species in warm seas, some reaching a very large size. Genera 2 or 3.

Genus HEPTRANCHIAS Rafinesque.

Heptranchias Rafinesque, Car. Nuov. An. Sicil., 1810, p. 13. Type *Squalus cinereus* Gmelin, monotypic.
Heptanchus, Heptancus, auct.
Aellopos Agassiz, Poiss. Foss., III, 1843, p. 376. Type *Aellopos wagneri* Agassiz, first species.
Notorynchus Ayres, Proc. Cal. Acad. Sci., I, 1856, p. 72. Type *Notorynchus maculatus* Ayres, monotypic.
Notorhynchus, auct.

Differs from *Hexanchus* in the presence of seven gill-openings. The fossils referred to this genus are only known from detached teeth. About 11 living, and about 33 extinct species have been described, mostly under the generic name *Notidanus*, which is properly a synonym of the earlier *Hexanchus*.

Heptranchias primigenius (Agassiz).

Notidanus primigenius Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362 (Cumberland Co., Miocene).

Lateral teeth wide, thin, and greatly compressed. Coronal region wide, polycuspid, faces similarly convex, smooth and compressed. Cutting-edges entire. Anterior cusp enlarged, well inclined externally, and followed by 6 or 7 similar ones graduated to last, latter quite small. Preceding largest cusp 6 to 10 anterior small graduated cusps, graduated down, first scarcely larger than penultimate or last of external cusps. Graduation of these cusps also slight, as all small. Apices of all cusps compressed, not twisted. Root compressed, rather thin, outer face flattened and inner bulging a little convexly. Lower margin entire or slightly convex. In transverse section root somewhat cuneate. Height of largest example 20 mm.

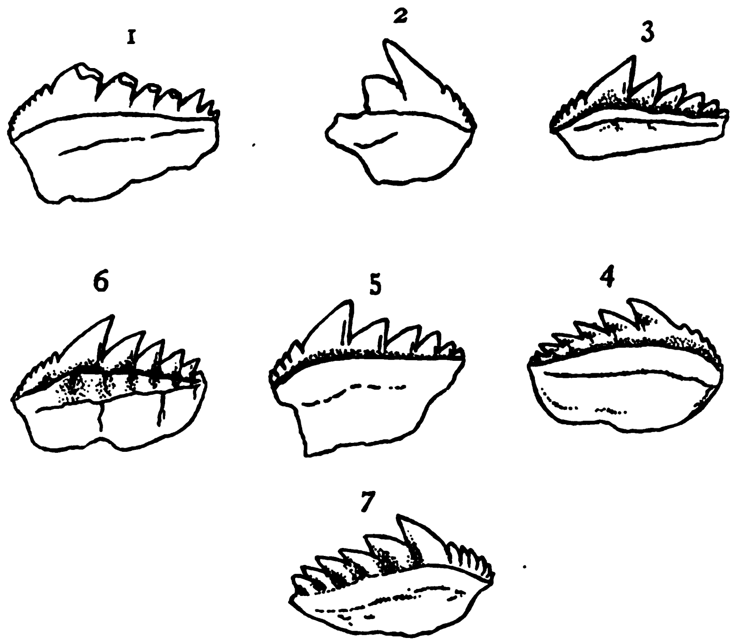

FIG. 1.—*Heptranchias primigenius* (Agassiz). 1–2, Allowaystown (Yarrow); 3–7, Charles Co., Md. (Thomas).

All of my examples agree largely with Agassiz's figures 16 and 17[1]. Eastman considers *H. plectrodon* Cope identical[2].

Formation and locality. This species was originally found in the State in Cumberland County, in Miocene beds. Known only from detached teeth. My examples are 4 teeth from Monmouth County (W. Cleburne) without formation, though possibly Eocene; 2 teeth from the Miocene [Eocene? K], of Shark River in Monmouth County (T. A. Conrad); and 3 teeth from Allowaystown, Salem County (H. C. Yarrow), without formation.

Genus XIPHODOLAMIA Leidy.

Xiphodolamia Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 252. Type *Xiphodolamia ensis* Leidy, monotypic.
Xiphodontolamia Leidy, l. c., nom. orig.

[1] Poiss. Foss., III, 1843, p. 218, Pl. 27, figs. 6–8, 13–17, (4–5 doubtful).
[2] Md. Geol. Surv. Miocene, 1904, p. 78.

Teeth awl-shaped, rather sigmoid, without any basal cusps, roots unequal or nearly equal and approximated.

Originally this genus was thought to be of uncertain relation. Woodward has suggested its relation with *Heptranchias*, pointing out that the teeth are apparently referable to the symphysis of the upper jaw of that genus[1]. Provisionally, at least, I retain it as distinct.

XIPHODOLAMIA ENSIS Leidy.

Xiphodolamia ensis Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 252, Pl. 34, figs. 25–30. *Vincentown, Monmouth County, Burlington County, Allowaystown, N. J.*

Teeth slender, compressed laterally. Crown smooth, usually sigmoid, sabre-like in form, front edge sharp and hind border obtuse. Outer surface flat, inner convex. Cutting-edge entire. Apex erect, slender, sharp-pointed. No cusps. Root with both sides apparently approximated, so that ends are directed obliquely and parallel, and these sometimes nearly equal. Outer

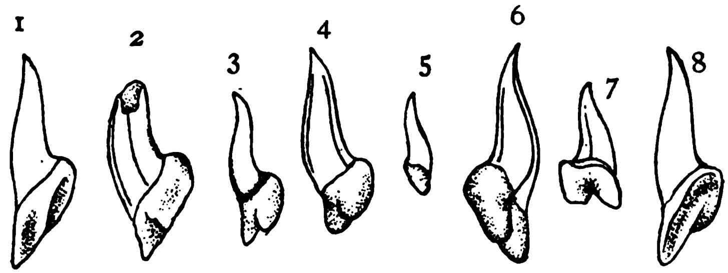

FIG. 2.—*Xiphodolamia ensis* Leidy. 1, Allowaystown (Yarrow); 2–5, Monmouth Co. (Knieskern); 6, Burlington Co. (Abbott); 7–8, Vincentown (Bryan).

surface depressed or concave, and inner bulging convexly, though inferiorly, inner surface also slopes down flattened. Length 28 mm.

This species is known only from the above described paratypes.

Formation and locality. I have examined Leidy's paratypes, doubtfully ascribed to the Cretaceous? of New Jersey. They

[1] Cat. Foss. F. Brit. Mus., I, 1899, p. 168.

are 4 teeth from Monmouth County (P. D. Knieskern); 4 from Vincentown [The Manasquan marl, K.] in Burlington County (T. M. Bryan); 1 from Burlington County (C. C. Abbott); 1 from Allowaystown, in Salem County (H. C. Yarrow). Originally there were 12 specimens in the Bryan collection, but I have only examined 4.

Order ASTEROSPONDYLI.

THE TYPICAL SHARKS.

Vertebral column well segmented, each segment forming a neural arch and one centrum. Vertebræ each with internal calcareous lamellæ radiating from central ring. Gill-openings 5. Dorsal fins 2. Anal fin present.

This order includes the greater number of living sharks.

Sub-Order PROARTHRI.

THE CESTRACIONT SHARKS.

Gill-openings 5, always lateral. Palato-quadrate apparatus articulated to preorbital part of skull. Dorsal fins 2, well developed, each with a large spine.

Usually three families are embraced in this group, all represented by fossil forms, and only one, the *Heterodontidæ*, is found living, with a few species in the Indo-Pacific.

Family HETERODONTIDÆ.

THE BULL-HEAD SHARKS.

Body robust in front. Head high, thick. Mouth small, narrow, 7 upper lip lobes and fold on lower lip. Teeth alike in jaws, small and obtuse in front, large and molar behind. Nostrils confluent with mouth. Gills 5. Spiracles small. Two dorsals, strong spine on each. Caudal tip notched usually. Oviparous, egg-cases spiral.

Genera 15, all represented by extinct forms with *Heterodontus* still existing.

Genus ACRODUS Buckland.

Acrodus Buckland, Geol. Mineral, Ed. 2, II, 1837. p. 47. Type *Acrodus nobilis* Buckland, monotypic.

Thectodus Meyer and Plieninger, Beitr. Pal. Württemb., 1844, p. 116. Type *Thectodus crenatus* Meyer and Plieninger, first species.

Teeth conic, non-cuspidate, crown mostly striated, with one principal elevation, and one or more lateral prominences in either side diminishing outwards. Root much or moderately depressed. Symphyseal teeth few, relatively large. Notochord persistent. Two large hooked-shaped semi-barbed dermal spines immediately after each eye. Shagreen sparse, consisting of small, conical, radiately-grooved tubercles, sometimes fused into groups of three. Dorsal fin-spines longitudinally ridged and grooved, ridges not denticulated, and two posterior longitudinal series of denticles, not marginal, but placed together mesially. Anterior dorsal spine longer and more slender than posterior.

This genus is closely related to *Hybodus* Agassiz, and differs only in the rounded and non-cuspidate character of its teeth. The dorsal fin-spines are also scarcely to be distinguished from those assigned to the same, their determination being based on their association and stratigraphical order. Altogether, possibly 55 species may be referred to this genus.

Acrodus humilis Leidy.

Acrodus humilis Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 163. *Limestone from New Jersey cretaceous.*

Leidy, Rep. Geol. Surv. Terr. Hayden, 1873, pp. 300, 352, Pl. 37, fig. 5 (type).

Tooth depressed. Crown smooth, evenly convex over its entire upper surface, greatest width not quite one-third its length, ends rather angular, and long edges broadly projecting over narrow base, with under surfaces nearly level or but slightly inclined. Upper surface of crown, though with smooth aspect, shows reticulations, which, though rather coarse along median axis soon become smaller, and along edges are very minute. Base width about one-half that of crown, with ridge anteriorly and groove

posteriorly along longitudinal surfaces, former not very high and latter shallow. Lower surface of base flat. Length (width) 16 mm.

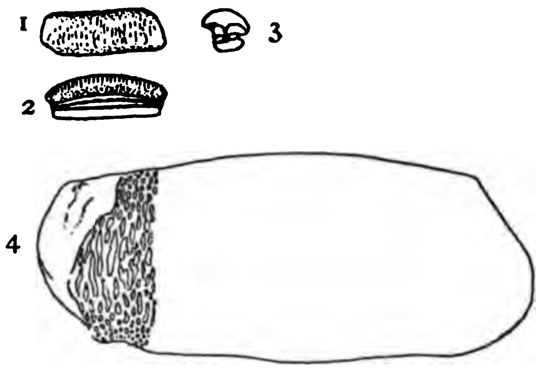

FIG. 3.—*Acrodus humilis* Leidy. (Type.) 1, upper view; 2, lateral view; 3, end view; 4, enlarged 4x.

Formation and locality. I have examined only the above example, the type ascribed to the "limestone from the New Jersey cretaceous," from Vincentown, in Burlington County [The Vincentown formation, K].

Sub-Order GALEI.

THE TRUE SHARKS.

Gill-openings 5, always lateral. Palato-quadrate apparatus not articulated with skull. Dorsal fins 2, well developed, each without spine.

This group contains the greater number of existing and fossil families of sharks.

Family GINGLYMOSTOMIDÆ.

THE NURSE SHARKS.

Eyes very small. Upper and lower lips developed, latter not extending across symphysis. Nasal and buccal cavities confluent. Nasal valves at both sides form one quadrangular flap before mouth, and each provided with a free cylindrical cirrus. Spiracle

minute behind eye. First dorsal above or after ventral, second opposite and somewhat before anal. Tail most abruptly bent up at base.

Large sharks of warm seas, referred to two genera.

Genus GINGLYMOSTOMA Müller and Henle.

Ginglymostoma Müller and Henle, Arch. Naturg., 1837, p. 396. (No species given.) Type *Squalus cirratus* Gmelin, virtually designated by Bonaparte, Nuov. An. Soc. Nat. Bologna, II, 1838, p. 212.

Plicodus Winkler, Arch. Mus. Teyler, III, 1874, p. 301. Type *Plicodus thielensis* Winkler, monotypic.

Acrodobatis Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 250. Type *Acrodobatis serra* Leidy, first species, designated by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 310.

Acrodontobatis Leidy, l. c., nom. orig.

Many series of teeth in jaws, each with a strong median cusp and one or two small basal cusps each side. Second dorsal nearly opposite anal. Tail about one-half rest of body.

About seven extinct and two existing species are known.

GINGLYMOSTOMA OBLIQUUM (Leidy).

Acrodobatis obliquum Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 250, Pl. 34, fig. 14. *Marl of Monmouth Co., N. J.*

Crown wider than high and base extended downward at middle in a rounded prominence, and backward posteriorly in a similar prominence. Summit arises in a tapering point, and lateral acute borders show seven denticles successively decreasing in size. Outer side presents two larger denticles succeeded by

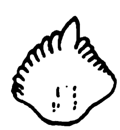

FIG. 4.—*Ginglymostoma obliquum* (Leidy). (From Leidy.)

four minute ones. Inner acute border of crown long, convex in its course from base of main point. Length 7 mm. (From Leidy.)

Though Leidy expressly states that the type of this species, a tooth only ¼ of an inch long, was presented to the Academy of Natural Sciences of Philadelphia by Dr. Knieskern, I have not located it among the collections. Leidy points out that it differs from *Ginglymostoma serra* in having the main point of the crown inclined to one side.

Formation and locality. Known only from the Eocene of New Jersey.

Family LAMNIDÆ.

THE MACKEREL SHARKS.

Body stout. Mouth wide. Teeth large, sharp. Gill-openings wide, all before pectorals, entirely lateral, not extending under throat. Spiracles minute or absent. First dorsal large. Second dorsal and anal very small. Tail slender. Caudal lunate, both lobes not very unequal and upper strongly bent upward. Caudal peduncle with strong lateral keel on each side. Pit at caudal root. Pectorals large. Ventrals moderate.

Large, fierce sharks in all seas, referred to eight or nine genera, of which three still persist to the present time. The muscular system and dentition reaches its greatest degree of specialization known among sharks in this family.

Genus ISURUS Rafinesque.

Isurus Rafinesque, Car. Nuov. Gen. Sicil., 1810, p. 11. Type *Isurus oxyrinchus* Rafinesque, monotypic.

Oxyrhina Agassiz, Poiss. Foss., III, 1836, pp. 87, 276. Type *Lamna oxyrhina* Valenciennes, monotypic.

Oxyrrhina, auct.

Isuropsis Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, pp. 398, 408. Type *Oxyrhina glauca* Müller and Henle, designated.

Anotodus LeHon, Prêl. Mém. Poiss. Tert. Belg., 1871, p. 8. Type *Anatodus agassizii* LeHon, monotypic.

Body mackerel or tunny-like, caudal peduncle slender. Snout rather long, pointed. Teeth long, lanceolate, cutting-edges sharp and entire, and no basal cusps. First dorsal large, entirely behind pectoral, or nearly midway between latter and ventral. Second dorsal and anal very small. Pectoral large.

About three existing and 39 fossil species have been referred to this genus.

ISURUS DESORII (Agassiz).

Oxyrhina minutus (nec Agassiz) Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Anterior teeth narrow, robust, much elevated and thick. Crown slightly curved inwards towards apex. Outer coronal surface more or less flattened, and inner well convex. Apex scarcely deflected. Cutting-edges entire. No basal cusps. Root thick, concave or flattened on outer surface, inner face with large, pronounced, bulging or convex surface, and each end a long divergent branch, often unequal and acute. Lateral teeth more compressed, root shorter and with more diverging ends, crown narrow, apex scarcely deflected, and usually entire cutting-edges gradually divergent to ends of base. Length varies to 54 mm.

According to Woodward this species differs from the existing *Isurus oxyrinchus* only in the less curvature of the lateral teeth. From worn and fragmentary examples of *Lamna elegans*, in which the inner coronal striæ seem to be obliterated, I cannot distinguish some material positively. Frequently the teeth of *Isurus* are more or less depressed basally on their inner surfaces. It is also almost impossible to distinguish the teeth of *Lamna cuspidata*, and no doubt a number of the teeth of the present species may be listed under that name. This form is known only from the detached teeth.

Formation and locality. A number of examples in the collections of the Academy from the Cretaceous marls, all without beds indicated, are: 1 tooth from "New Jersey" (E. D. Cope), 2 teeth from Deal [probably from Manasquan marl, K.] (Breed), 1 from Monmouth County (C. C. Abbott) and 8 more from the same region (W. Cleburne), 3 from Burlington County (T. A. Conrad), 5 from Vincentown [Manasquan marl or Vincentown limesand, K.] (T. M. Bryan), 2 from 5 miles from Mullica Hill (Abbott) and 1 from the latter locality [Navesink-Hornerstown marl, K.] (J. Da Costa) and 7 from Allowaystown in Salem County (H. C. Yarrow).

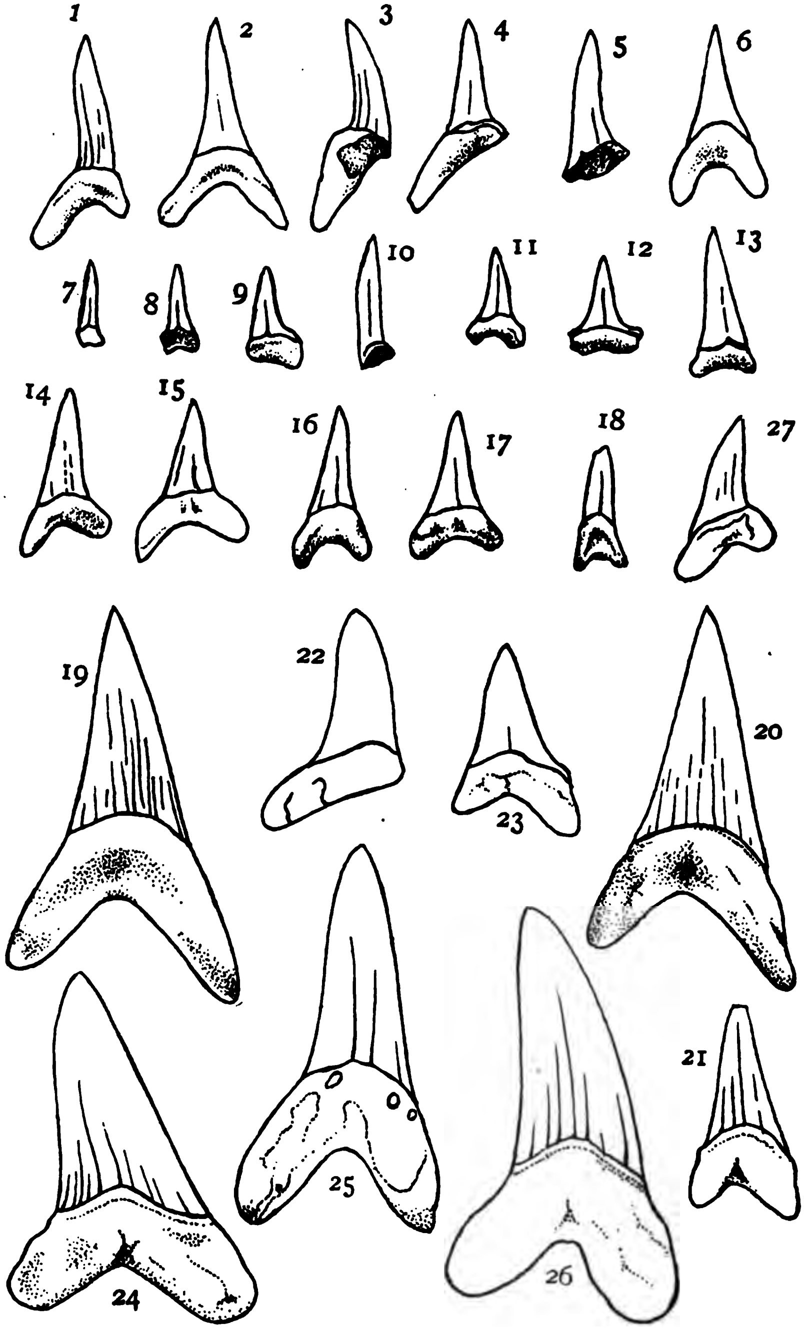

FIG. 5.—*Isurus desorii* (Agassiz). 1–22, Charles Co., Md. (Thomas); 22, Monmouth Co. (Cleburne); 23, Vincentown (Bryan); 24, Mullica Hill (Abbott); 25–26, Mullica Hill (Da Costa); 27, Charles Co., Md. (Thomas).

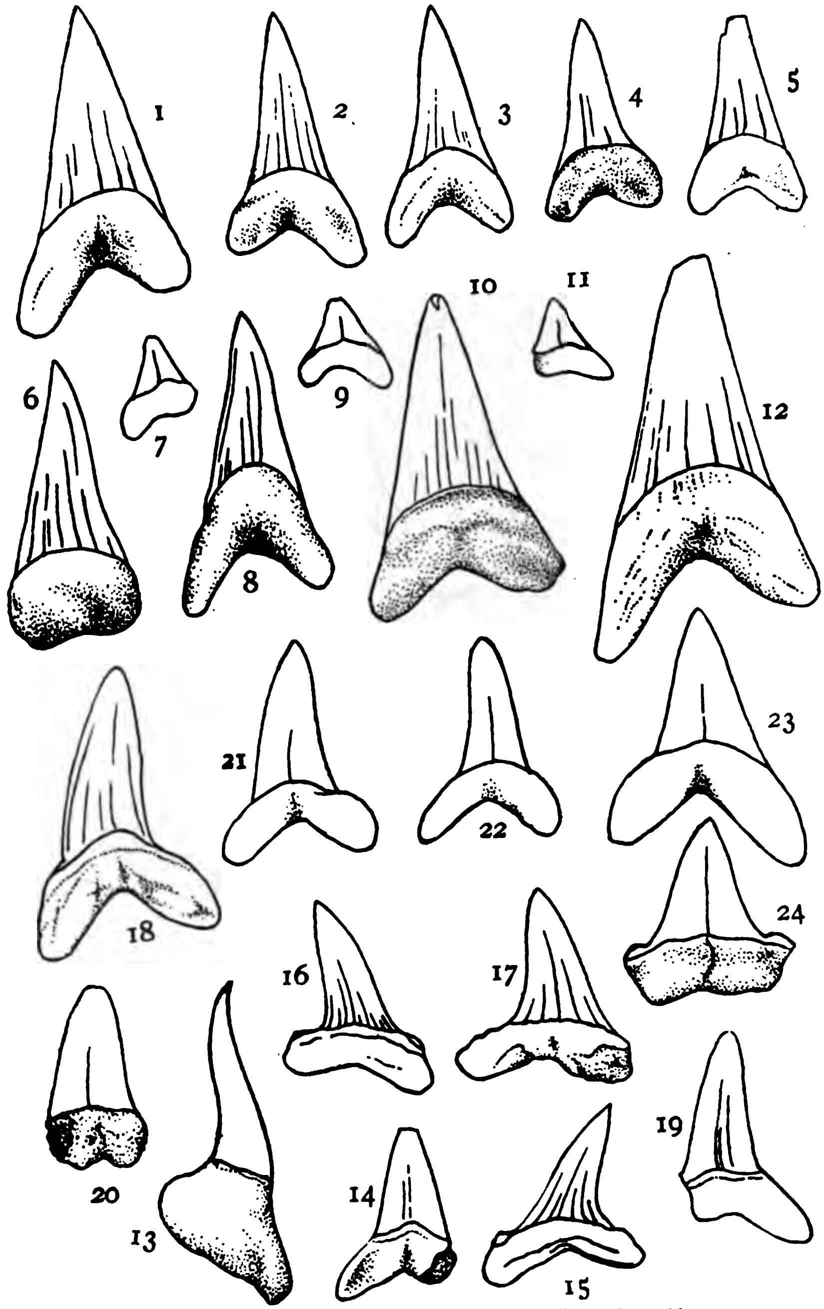

FIG. 6.—*Isurus desorii* (Agassiz). 1–13, Charles Co., Md. (Thomas); 14, Deal (Breed); 15–17, Monmouth Co. (Knieskern); 18–19, Monmouth Co. (Abbott); 20–24, Vincentown (Bryan).

Abbott's Monmouth County example is more compressed at the crown than the other examples. It also has flaring trenchant edges, and its inner face basally is swollen. His Mullica Hill examples agree largely with Da Costa's, which, in turn, differ from Maryland Miocene examples[1] in the slightly deflected crown, the latter more convex on its inner surface.

The present species does not seem to have been recorded previously from New Jersey, except if confused with *Isurus minutus*, as contended by Eastman.

In the Geological Survey collection I have examined 2 teeth without data, and 34 from Shiloh in Cumberland County (E. Davis) [from the so-called Shiloh marl of the Kirkwood (Miocene) formation, K.], probably belonging to this species.

Isurus hastalis (Agassiz).

Oxyrhina xiphodon Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362 (Cumberland Co. Miocene).

Anterior teeth broad, thin, compressed, widely triangular. Crown slightly curved outward towards apex. Outer coronal surface flat or slightly concave, rarely with basal vertical wrinkles, and inner surface moderately and evenly convex. Apex usually deflected a little laterally. Cutting-edges entire. Sometimes an obselete broad short convex basal cusp at one or each side of base. Root short, with usually blunt obtuse edges, outer surface flattened or slightly concave, inner surface moderately convex, and lower profile a little emarginated. Lateral teeth with coronal edges gradually curving to ends of base, and apex often slightly deflected externally. Length reaches 47 mm.

This species is known only from its detached teeth, usually to be identified by their broad and thin appearance. Woodward says it is almost impossible to distinguish many of the posterolateral teeth from those of *Isurus desorii* and the existing *Isurus oxyrinchus*. He suggests *Otodus apiculatus* Agassiz, with a rudimentary lateral denticle as a synonym. The present species does not seem to be very numerous among New Jersey fossils.

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[1] *Oxyrhina desorii* Cope, Proc. Acad. Nat. Sci. Phila., 1867, p. 142.

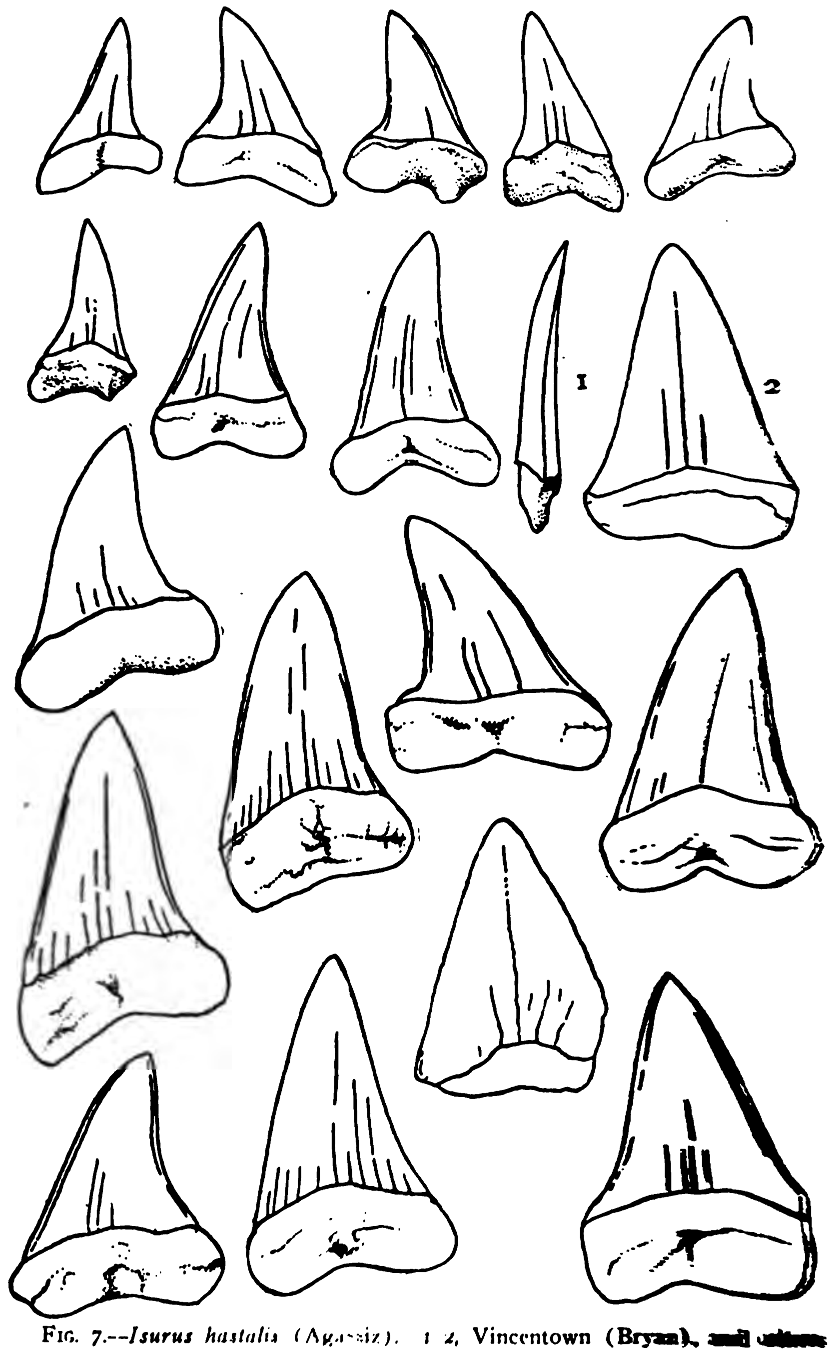

FIG. 7.--*Isurus hastalis* (Agassiz). 1 2, Vincentown (Bryan), and others from Charles Co., Md. (Thomas).

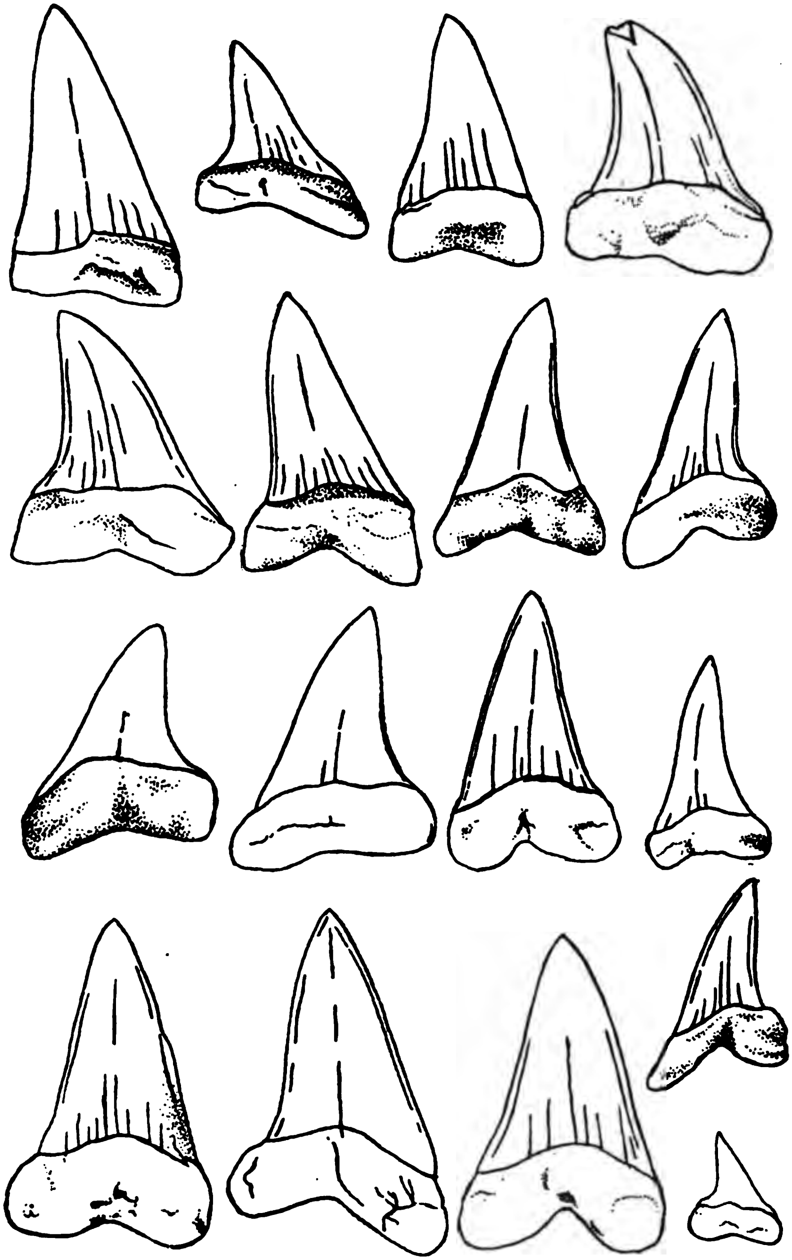

FIG. 8.—*Isurus hastalis* (Agassiz). Charles Co., Md. (Thomas).

Formation and locality. I have 7 teeth from the marls [Manasquan formation, K.] at Vincentown (T. M. Bryan), also 2 from Delaware (P. Uhler).

ISURUS ACUMINATUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 11. *New Jersey.*

Lamma acuminata (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 4. *No locality.*

Lamma mantelli (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835. p. 277 (name only, based on preceding).

Teeth moderately robust, compressed, and vary from widely angular to acuminate. Crown slightly curved out toward apex. Outer coronal surface mostly flattened, sometimes a few vertical basal wrinkles, and inner surface moderately and evenly convex. Apex usually deflected slightly to one side. Cutting-edges entire. Sometimes a low, obsolete, broad, basal cusp at one or each side of base, variable. Root short, with usually obtuse edges, outer surface flattened or concave, inner surface moderately convex, and lower profile a little emarginated. Anterior teeth comparatively wide, with only a gentle curved crown, and lateral teeth with root much broader than crown, thus forming a sudden basal expansion behind and often anteriorly. Length reaches 40 mm.

Known only from detached teeth. Although this species is usually known by the specific name *mantelli*, Agassiz's name *acuminata* occurs first on the same page in Morton's work. Morton's figure is rather incomplete, though it shows a basal cusp. His figure of *mantelli*, though also crude, represents a much larger tooth, and is probably the same as the one Agassiz publishes later.

Formation and locality. The following examples appear to belong to this species, most all evidently from the Cretaceous marls. They are: 5 imperfect teeth from "New Jersey" (C. C. Abbott), 2 from the same (Burtt), 10 from Monmouth County (W. Cleburne), 1 from the same without donor, 1 from the same (P. D. Knieskern), 5 from the Miocene formation of

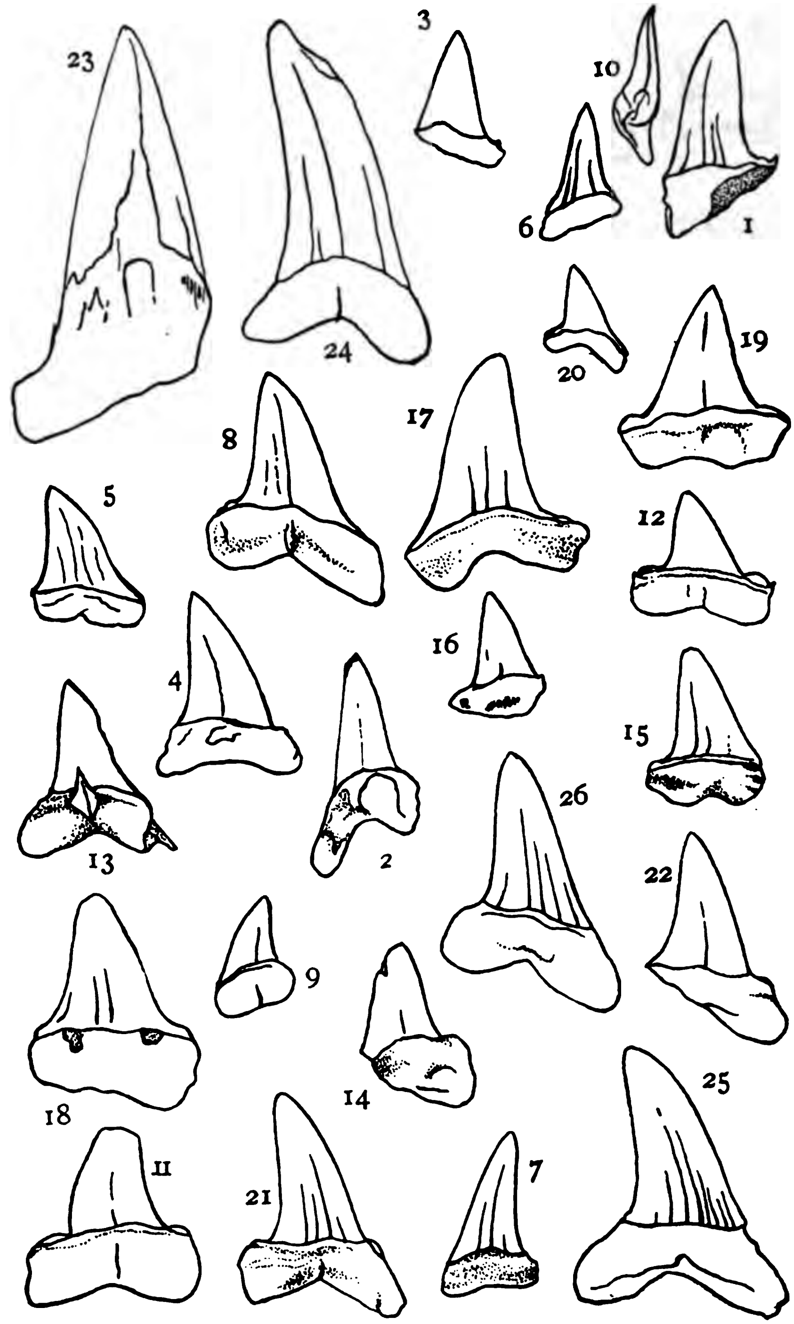

FIG. 9.—*Isurus acuminatus* (Morton). 1–2, New Jersey (Abbott): 3, Deal; 4–6, Shark River (Conrad); 7, Long Branch; 8–16, Monmouth Co. (Cleburne); 17, Monmouth Co. (Breed); 18–19, Vincentown (Bryan); 20, Burlington Co. (Conrad); 21–21, Mullica Hill (Abbott); (23–24 are *Isurus desorii*) 25–26, Allowaystown (Yarrow).

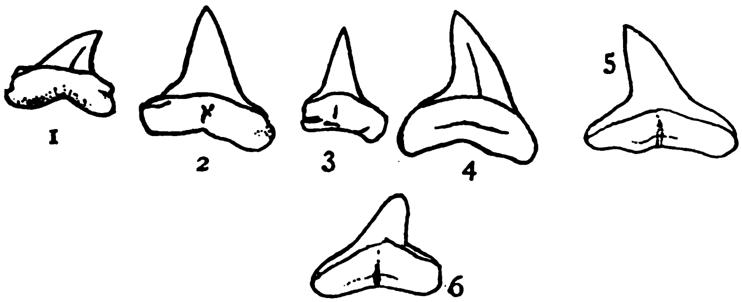

FIG. 10.—*Isurus acuminatus* (Morton). 1, Burlington Co. (Conrad); 2, Monmouth Co. (Knieskern); 3, Bridgeton (H. B. Abbott); 4, Burlington Co. (Conrad); *5–6, Vincentown (Dick).

Shark River (T. A. Conrad), 1 from Deal [Manasquan or Shark River formations, probably the former, K.] and 3 from Long Branch [Hornerstown ? K.], all without donor, 2 from Burlington County (T. A. Conrad), 2 from Vincentown [Manasquan formation, K.] (T. A. Bryan), 2 from Mullica Hill [Navesink marl ? K.] in Gloucester County (C. C. Abbott), 2 from Allowaystown in Salem County (H. C. Yarrow), and 1 from the Miocene of Cumberland County along the "Bridgeton Pike" (C. C. Abbott).

ISURUS SILLIMANII (Gibbes).

Oxyrhina minutus (nec Agassiz) Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Teeth moderately compressed, rather thin, and formed as a moderate isoceles triangle. Crown variably curved slightly outward, or inwards toward apex. Outer coronal surface flattened or slightly convex, inner surface flattened or slightly convex, and latter without basal vertical folds. Apex deflected, sometimes strongly so, to one side. Cutting-edges entire. Usually at base on either or each side one or two obsolete broad cusps, low, and their edges also entire. Roots short or moderate, outer surface flattened or slightly concave, inner surface bulging in prominent convexity, and lower profile forming a moderate emarginate blunt angle. Ends of roots deep, though not produced. Reaches a length of 34 mm. This description from 24 examples from the Calvert formation of Charles County, Md., in the Miocene.

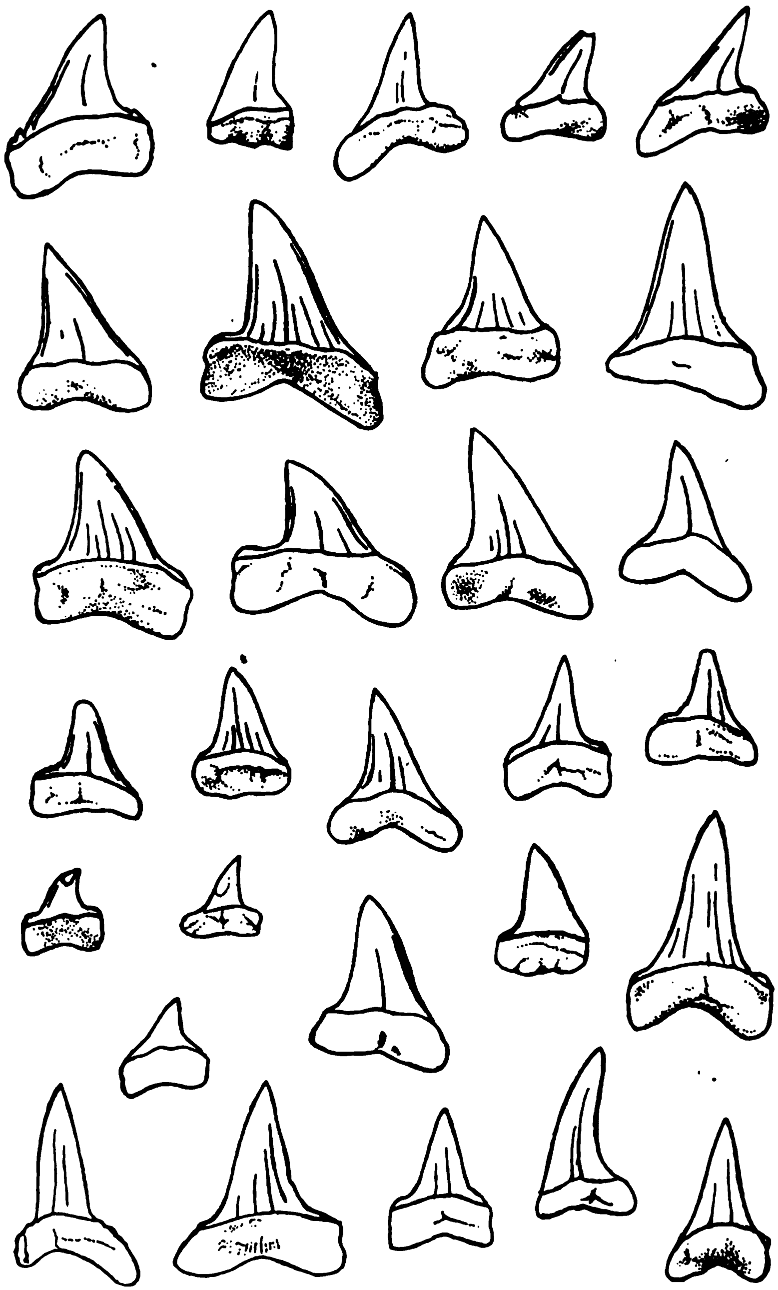

FIG. 11.—*Isurus sillimanii* (Gibbes). Charles Co., Md. (Thomas).

I have included this species entirely on the authority of Dr. Eastman,[1] who says that Cope partly, at least, determined apparently young examples of the present species as *Oxyrhina minutus*. The former also states that Cope's determination is further practically incorrect, and that some are *Isurus desorii* and others *Eulamia*.

Formation and locality. Cope's material was from the Miocene of Cumberland County.

Isurus sp.

Oxyrhina sp. Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4.)

A species with flat but narrower crown than the last [*Oxyrhina extenta* Leidy], and with perfectly smooth cementum, the base of the latter being serrulate in the convex side of the crown. No denticles. Crown with a lateral curvature. (From Cope.)

Formation and locality. Common in the "greensand, No. 4, New Jersey," according to Cope, though I have no examples.

Isurus sp.

Oxyrhina sp. Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4.)

With crown flatter and broader than the last; frequently oblique, but not curved, and not infrequently with lateral denticles. Cementum smooth, except a short distance from the base on the convex side striate-grooved. (From Cope.)

Formation and locality. Common in the "greensand, No. 4, New Jersey," according to Cope. It seems possible this may belong with *Lamna elegans*, representing its short posterior teeth.

Genus LAMNA Cuvier.

Lamna Cuvier, Regne Animal, II, 1817, p. 126. Type *Squalus cornubicus* Gmelin, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VIII, 1861, p. 32.

Lamia Risso, H. N. Eur. Merid., III, 1826, p. 123. Type *Squalus cornubicus* Gmelin, monotype. (Preoccupied in insects.)

Selanonius Fleming, Brit. An., 1828, p. 169. Type *Squalus selanoncus* Walker, monotype.

[1] Md. Geol. Surv. Miocene, 1904, p. 81.

Body short, stout, back somewhat elevated. Snout prominent, pointed. Teeth triangular, pointed, entire, each with one small basal cusp on each side, though cusps sometimes obsolete on some teeth in young. Gill-openings wide. First dorsal and pectoral fins somewhat falcate, former close behind pectoral bases. Second dorsal and anal very small, nearly opposite one another.

Large fierce sharks in most cool seas, to which three existing species and about 34 extinct have been referred.

LAMNA CUSPIDATA Agassiz.

Lamna cuspidata Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (Probably New Jersey Cretaceous.)

Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lamna denticulata Cope l. c. (Cumberland Co. Miocene.)

Anterior teeth usually long, slender, compressed and moderately triangular, scarcely sigmoid in character. Crown usually slender, subulate, erect or sometimes diverging outwards. Outer coronal surface flattened or but slightly convex, smooth. Inner coronal face usually well convex, sometimes little flattened medianly, and entirely smooth. Apex erect or variously deflected. Cutting-edges prominent, entire. Usually one, sometimes two, small acute basal cusps on one or each side. Root large, outer face concavely depressed, and inner convexly bulging till very pronounced, the convexity usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between branches usually well marked. Lateral teeth broader, shorter, especially crowns, which are often well deflected, wider angle between branches of base and basal cusps varying quite broad. Length reaches 43 mm.

This is a very common fossil in the New Jersey marls and I have examined many teeth. This species is known only from detached teeth, scarcely distinguishable in many instances from those of *Isurus acuminatus*. The teeth may also be confused with those of other related sharks, though they do not appear to reach quite so large a size as the well-marked *Lamna elegans*. From *Isurus desorii* it may often be distinguished by the pres-

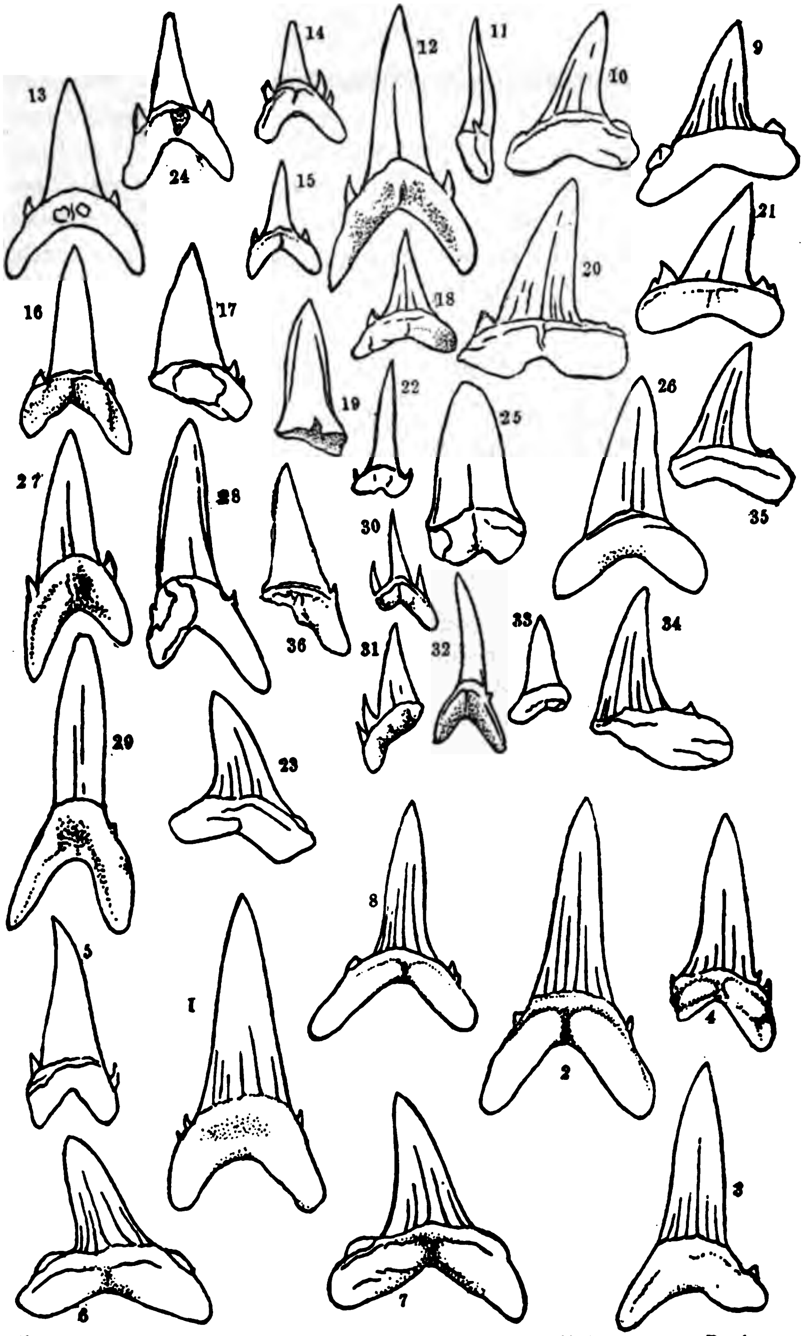

FIG. 12.—*Lamna cuspidata* Agassiz. 1, Farmingdale (Pilsbry); 2–3, Pemberton (Budd); 4, Monmouth Co. (Knieskern); 5, Vincentown (Bryan); 6–7, Burlington Co. (Conrad); 8, Monmouth Co. (Knieskern); 9–13, Burlington Co. (Budd); 14–15, Burlington Co. (Conrad); 16–21, Pemberton (Budd); 22–23, Allowaystown (Yarrow); 24–35, Vincentown (Bryan); *36, Shark R. (A. Shafter).

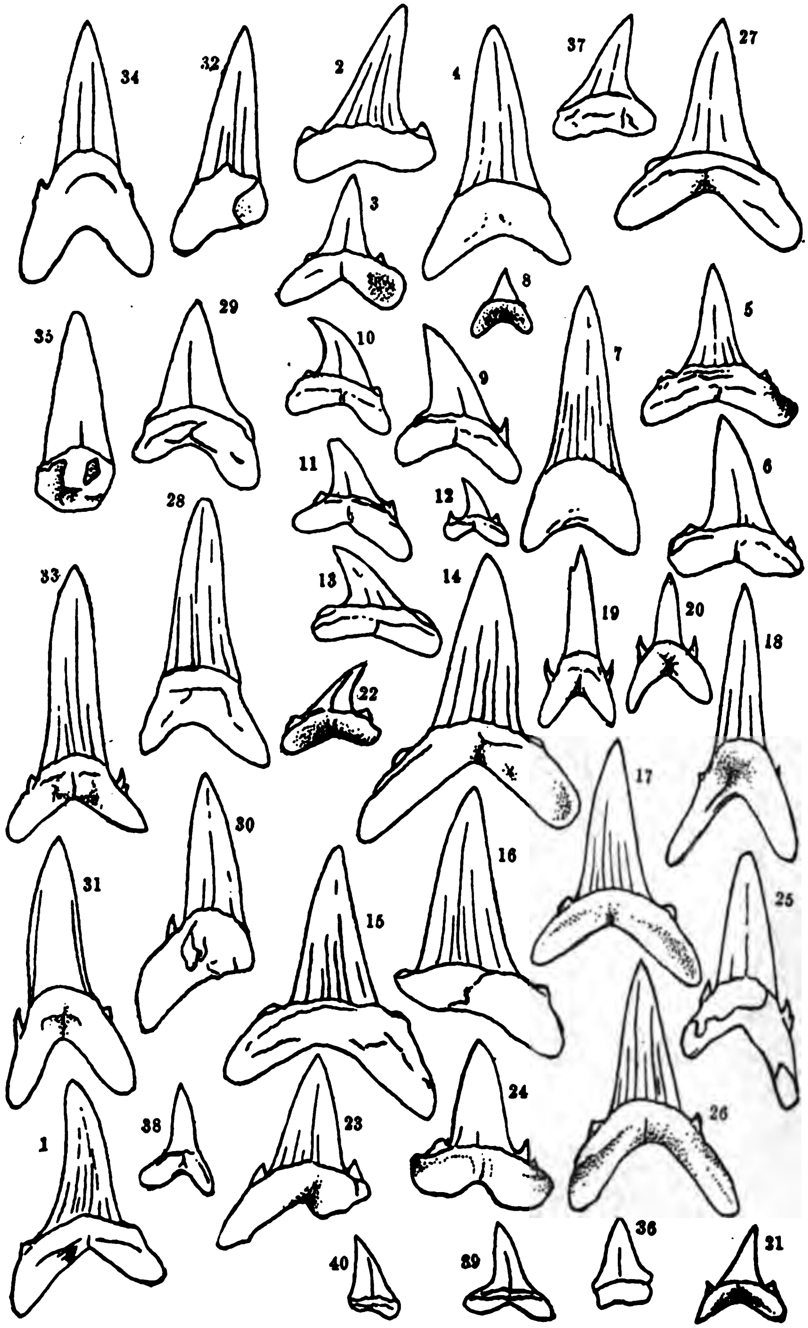

FIG. 13.—*Lamna cuspidata* Agassiz. 1–4, Monmouth Co. (Knieskern); 5–8, Monmouth Co. (Cleburne); 9, Monmouth Co. (Cleburne and Abbott); 10, Monmouth Co. (Cleburne); 11–12, Monmouth Co. (Cleburne and Abbott); 13–18, Burlington Co. (Conrad); 19–20, Burlington Co. (Budd); 21–22, Burlington Co. (Conrad); 23–26, Pemberton (Budd); 27, Allowaystown (Yarrow); 28–40, Vincentown (Bryan).

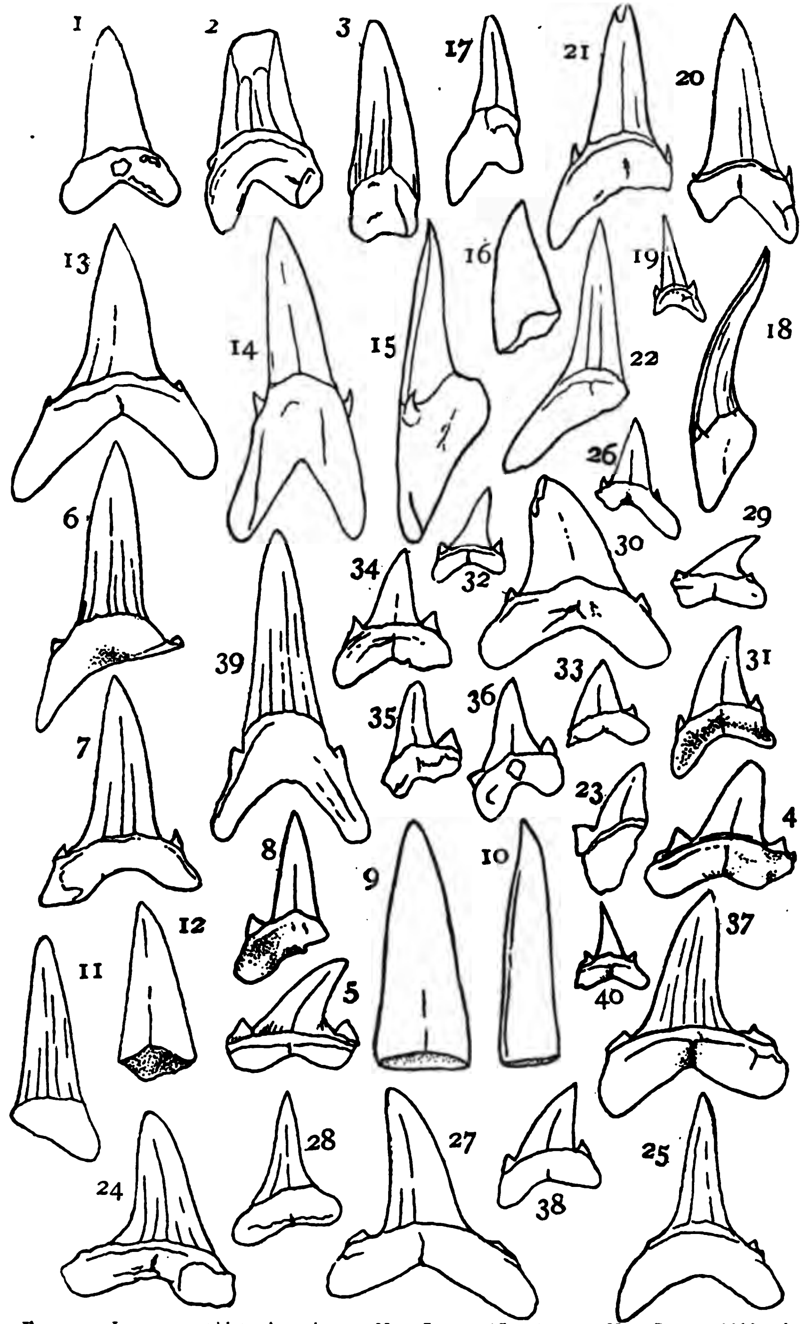

FIG. 14.—*Lamna cuspidata* Agassiz. 1, New Jersey (Cope); 2–3, New Jersey (Abbott); 4–5, New Jersey (Kilvington); 6–8, Shark R. (Conrad); 9–10, Long Branch (Chapman); 11–12, Long Branch; 13–17, Monmouth Co.; 18, Monmouth Co. (Knieskern and Abbott); 19–22, Monmouth Co. (Knieskern); 23, Monmouth Co. (Abbott); 24–26, Monmouth Co. (Knieskern and Abbott); 27–28, Monmouth Co. (Cleburne); 29–33, Monmouth Co. (Knieskern and Abbott); 34–36, Monmouth Co. (Cleburne); 37, Burlington Co. (Budd); 38, Burlington Co. (Conrad); 39, Farmingdale (Pilsbry); 40, Burlington Co. (Conrad).

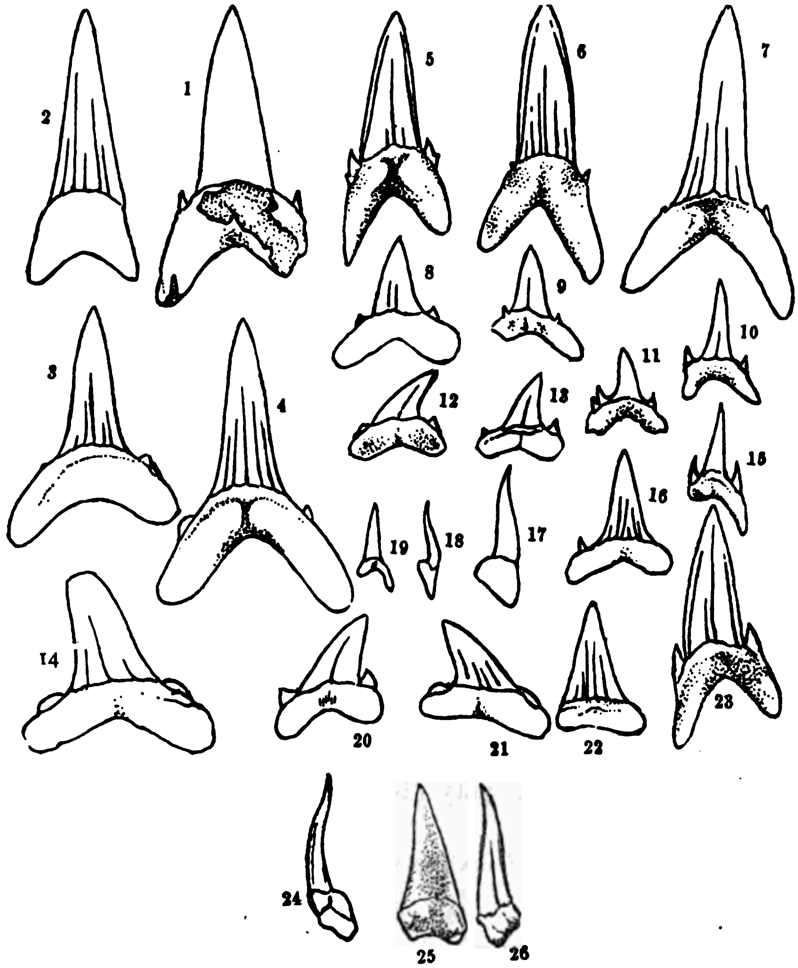

FIG. 15.—*Lamna cuspidata* Agassiz. 1, Vincentown (Bryan); 2–4, Monmouth Co. (Knieskern); 5–7, Vincentown (Bryan); 8–9, Monmouth Co. (Knieskern); 10–13, Burlington Co. (Conrad); 14, Burlington Co. (Conrad); 15, Vincentown (Bryan); 16, Pemberton (Budd); 17–19, Vincentown (Bryan); 20–21, Burlington Co. (Conrad); 22, Allowaystown (Yarrow); 23, Vincentown (Bryan); *24, Farmingdale (Johnson); *25–26, Farmingdale.

ence of small pointed basal cusps. Some of the specimens listed below may belong really to *Isurus desorii, I. acuminatus,* or others.

Formation and locality. The following teeth, none of which have the formation given, are in the collection of the Academy:

From "New Jersey" 3 (E. D. Cope), 8 (C. C. Abbott), 3 (P. D. Knieskern), 3 (Kilvington); Monmouth County 40 without donor, 18 (Knieskern), 178 (W. Cleburne), 1 (Abbott), 95 (Abbott and Knieskern); Farmingdale 2 (H. A. Pilsbry); Shark River 5 without donor and 26 (T. A. Conrad); Long Branch 20 without donor and 3 (H. C. Chapman); Burlington County 99 (Conrad) and 21 (C. Budd); Pemberton 31 (Budd); Vincentown 127 (T. A. Bryan); Allowaystown in Salem County 13 (H. C. Yarrow). [The geological horizons from which these came are probably as follows: Farmingdale, the Manasquan marl; Shark River, the Shark River marl (Eocene), perhaps the Manasquan marl; Long Branch, the Hornerstown or Manasquan; Pemberton, Manasquan; Vincentown, Manasquan marl, less probably the Vincentown limesand; Allowaystown, the Kirkwood (Miocene) K.]

In the collection of the Geological Survey I have found the following teeth: From the upper marl of Shark River [Eocene, K.] 8 (A. Shafter's pits), the upper marl [Manasquan, ? K.] of Farmingdale 1 (Johnson's pits). Manasquan marl, 1 mile south of Farmingdale, 9 fragmentary crowns without basal cusps, probably 7 teeth from Shiloh [Miocene, K.] (E. Davis), 1 from top of the Red Bank sand at Hornerstown, 104 from Monmouth County (Knieskern), and 5 without data.

LAMNA ELEGANS Agassiz.

Lamna elegans Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (New Jersey Cretaceous.)
Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Anterior teeth long, slender, compressed and moderately triangular, scarcely sigmoidal in profile. Crown usually slender, subulate, erect or sometimes diverging outwards. Outer coronal surface flattened or but slightly convex, smooth. Inner coronal surface usually well convex, sometimes little flattened in middle, and marked with very many fine, delicate parallel vertical striæ. Apex erect or variously deflected. Cutting-edges prominent, entire. Usually one, sometimes two, small acute basal cusps in one

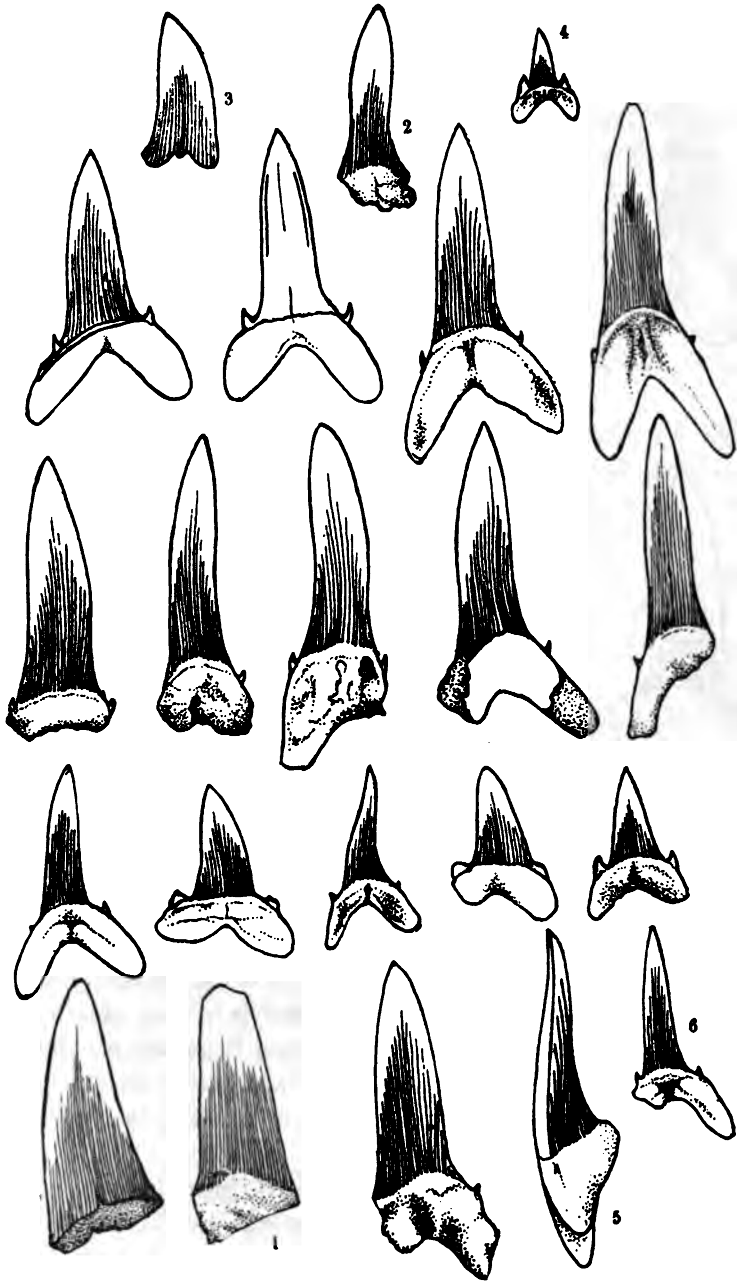

FIG. 16.—*Lamna elegans* Agassiz. 1–3, Deal; 4–6, Monmouth Co.; others from Vincentown (Bryan).

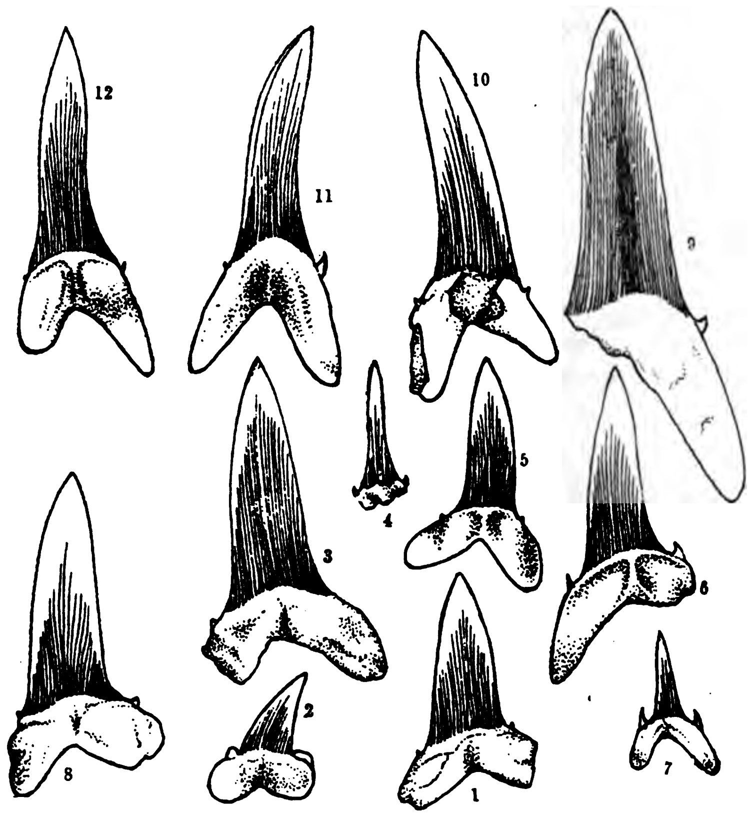

FIG. 17.—*Lamna elegans* Agassiz. 1, New Jersey (Cope); 2, Monmouth Co. (Knieskern); 3, Pemberton (Budd); 4–6, Vincentown (Slack); 7–12, Vincentown (Bryan).

or each side. Root large, outer face concavely depressed, and inner convexly bulging till very pronounced, the convexity usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between branches usually well marked. Lateral teeth with lower crowns, often well deflected, wider angle between branches of root and basal cusps varying till quite broad. Length to 65 mm.

This well-marked species is easily distinguished, when not worn, from the other species of the genus by the fine vertical striæ in the inner coronal surface. It is quite variable, and in the variation of form closely resembles *Lamna cuspidata.*

Formation and locality. The following teeth are all from the Cretaceous and Eocene marls, without formation: New Jersey 5 (C. C. Abbott), 2 (E. D. Cope); Monmouth County 15 without donor, 68 (J. H. Slack, J. Parke, J. H. Powell, Jr., and Abbott), 17 (P. D. Knieskern), 3 (Knieskern and Abbott); Deal 84 no donor; Long Branch 11 no donor, 14 (H. C. Chapman); Shark River 1 (T. A. Conrad) and 3 (Knieskern); Farmingdale 6 (H. A. Pilsbry); Burlington County 10 (Conrad) and 8 (C. Budd); Pemberton 33 (Budd); Vincentown 188 (T. A. Bryan); Medford 1 (L. Woolman); Mullica Hill 1 (W. M. Gabb); Bridgeton 5 (Budd) and 1 (C. B. Barrett). The last are evidently Miocene.

In the Geological Survey collection I have examined the following teeth: From the Wenonah sand a little less than 1 mile southeast of Cranford's Corner 4 (J. Longstreet's pit), Manasquan marl 1 mile south of Farmingdale 11 mostly fragmentary, Shiloh [Miocene, K.] 4 (E. Davis), Woodbury clay east of Matawan 3 (D. Farry's brickyards), middle marl [Manasquan, ? K.] at Riddleton 2 (Hackett's pits), upper marl [Manasquan, K.] at Poplar 7, and 4 without data.

[The geological range of these specimens is from the Woodbury clay, Cretaceous, into the Miocene, K.]

LAMNA MUDGEI Cope.

Lamna mudgei Cope, Rep. U. S. Geol. Surv. Terr. Hayden. II. 1875, p. 297, Pl. 42. figs. 11–12. *Niobara epoch of Kansas. Greensand No. 4, of New Jersey.*

Indicated by three teeth from the Niobara epoch of Kansas, and one from the greensand. "No. 4." of New Jersey. These teeth are rather stout, especially at the base, and the crown not

FIG. 18.—*Lamna mudgei* Cope. From Cope.

very elongate. The root is excessively protuberant, projecting horizontally beyond the convex side, and flat or truncate below the protuberance. The enamel is entirely smooth. Measurements of the New Jersey specimen: Length of crown, 14 mm.; diameter of base, longitudinal, 4 mm.; transverse, 7 mm.; long diameter of roots at basis of crown, 8 mm. (From Cope.)

The above description seems to be all that is known of this species in New Jersey.

Formation and locality. As given above, these fossils are Cretaceous.

LAMNA TEXANA Roemer.

Lamna sp. Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (New Jersey Cretaceous.)

Lamna texana Leidy, Rep. U. S. Geol. Surv. Terr. Hayden, 1873, p. 304, Pl. 18, figs. 46-47. (Clay near Haddonfield, in Camden Co., and Cretaceous greensand of Mullica Hill, in Gloucester Co.)

Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4 of New Jersey.)

Anterior teeth long, slender, compressed, scarcely sigmoid in profile. Crown slender, moderately thickened, erect. Outer coronal surface flattened or but slightly convex, and smooth. Inner coronal surface convex, sometimes little depressed basally, and marked at least over greater extent basally with prominent vertical striæ. These striæ more sparse than in related species. Apex erect, scarcely deflected. Cutting-edges prominent, entire. No basal cusps. Root large, outer surface concavely depressed, and inner bulging in prominent convexity, usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between usually well marked. Length reaches 48 mm.

Leidy first notices the two teeth ascribed to this species from clay near Haddonfield, which he found with a skeleton of *Hadrosaurus foulkii* and shells of *Exogyra costata, Ammonites placenta,* etc. This species is only known from detached teeth, and may be distinguished from *Lamna elegans* by the coarser striæ on the outer coronal surface.

Formation and locality. Known from the Cretaceous. I have 26 teeth from Mullica Hill [Navesink-Hornerstown marl, K.]

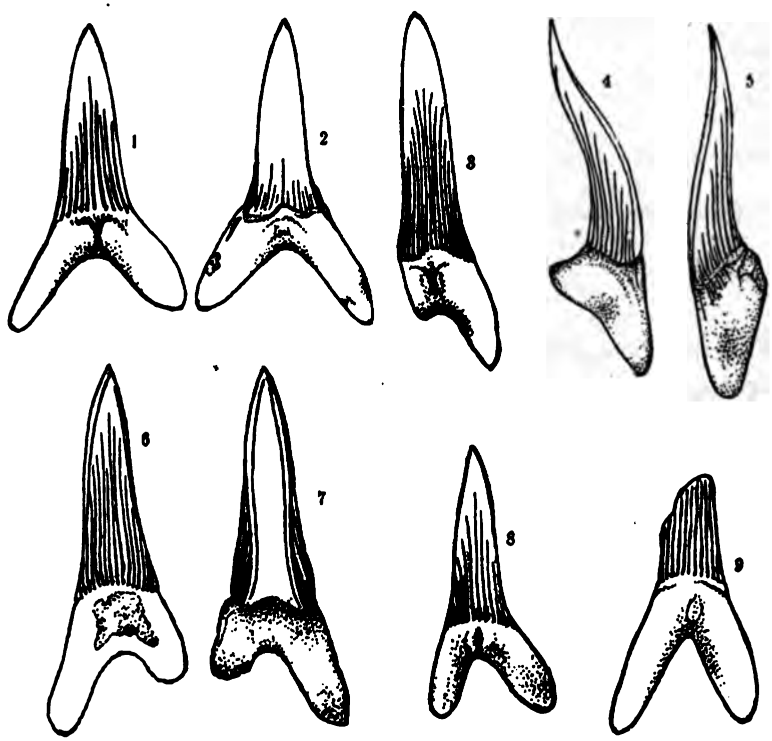

FIG. 19.—*Lamna texana* Roemer. 1–2, Pemberton (Budd); 3–4, Vincentown (Bryan); 5–8, Haddonfield; 9, Mullica Hill (Gabb).

(W. M. Gabb), 2 from Haddonfield [Woodbury clay K.] (J. Leidy), 1 from Vincentown [the Manasquan ? marl, K.] (T. M. Bryan) and 1 from Pemberton [Manasquan marl K.] (C. Budd).

Genus OTODUS Agassiz.

Otodus Agassiz, Poiss. Foss., III, 1843, pp. 266, 307. Type *Otodus obliquus* Agassiz, first species, restricted by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 304.

A provisional genus, embracing species evidently of large size, and known only from the teeth, which are large, thickened, though somewhat compressed, elongately triangular, with sharpened and entire cutting-edges, and 1 or 2 rather large cusps each side basally. Roots also large and thickened.

All the species, of which about 38 have been described, are extinct.

OTODUS APPENDICULATUS Agassiz.

Otodus appendiculatus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199. (New Jersey Greensand.)
Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)
Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand No. 5, N. J.)

Teeth robust, thickened and moderately compressed. Coronal surface slightly compressed, usually low or but moderately attenuated and sharply pointed. Outer face usually more or less flattened, or but slightly convex and smooth, sometimes a little concave basally, but without any vertical wrinkles. Inner coronal face usually well convex, rather prominently so basally, and smooth. Apex slightly deflected or erect. Cutting-edges trenchant, sharp, entire. Usually one large basal cusp on one or each side, sometimes two. These cusps vary from broad till quite slender, and are always sharply pointed and with entire cutting-edges. Root robust, thick, outer face usually flattened and inner face swelling in a large convexity. In profile lower margin varying rather widely crescentic, and ends sometimes flaring a little. Length to 36 mm.

This species seems to differ from *Otodus lanceolatus* chiefly in its smaller size. According to Woodward the anterior teeth are erect and slender, and the lateral teeth well inclined back, their front edges being more arcuate and longer than the hind ones. He further says that the thick root has the nutrative foramen not in a groove, and the outer coronal face has often a few indefinite vertical folds on its basal half.

Formation and locality. I have examined a number of detached teeth from the Cretaceous formations. They are: "New Jersey" 2 (T. A. Conrad), 1 (Burtt), 2 (W. M. Gabb), 1 without donor, 3 (C. C. Abbott); Monmouth County 1 (W. Cleburne), 3 (P. D. Knieskern and Cleburne), 3 (Abbott); Shark River 1 (Knieskern); Long Branch 4 (H. C. Chapman); Burlington County 4 (C. Budd); Crosswicks 1 (Conrad); Vin-

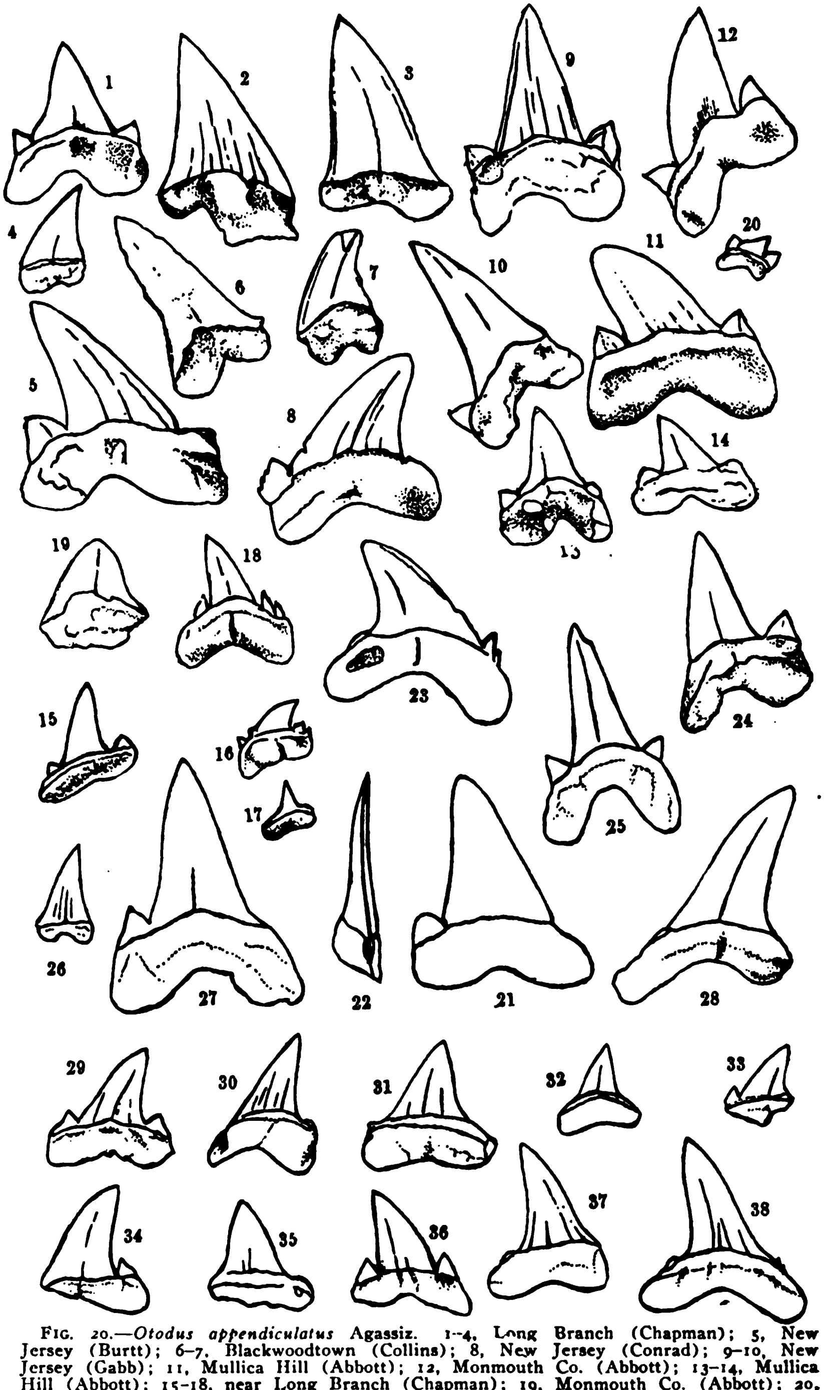

FIG. 20.—*Otodus appendiculatus* Agassiz. 1–4, Long Branch (Chapman); 5, New Jersey (Burtt); 6–7, Blackwoodtown (Collins); 8, New Jersey (Conrad); 9–10, New Jersey (Gabb); 11, Mullica Hill (Abbott); 12, Monmouth Co. (Abbott); 13–14, Mullica Hill (Abbott); 15–18, near Long Branch (Chapman); 19, Monmouth Co. (Abbott); 20, Monmouth Co.; 21–22, New Jersey (Conrad); 23–38, Vincentown (Bryan).

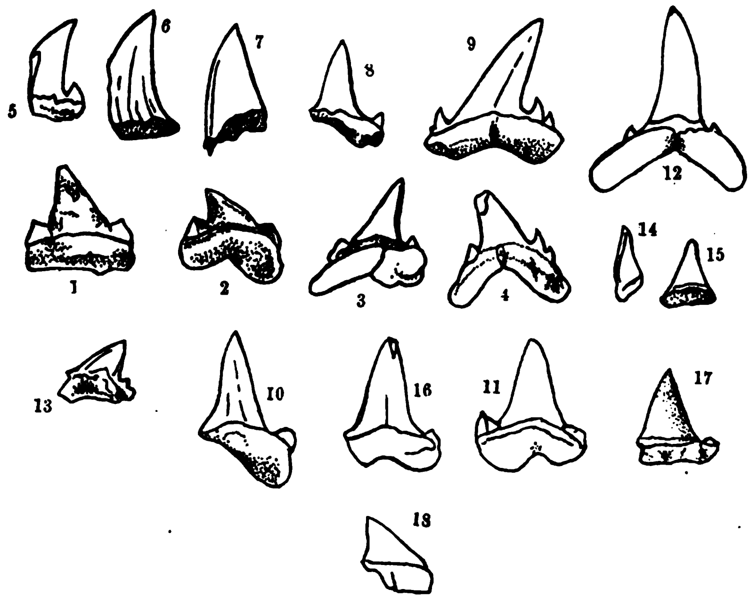

FIG. 21.—*Otodus appendiculatus* Agassiz. 1–2, Charles Co., Md. (Thomas); 3, Allowaystown (Yarrow); 4, Monmouth Co. (Cleburne); 5–7, Burlington Co. (Budd); 8, Shark R. (Knieskern); 9, Vincentown (Bryan); 10, Monmouth Co. (Knieskern and Cleburne); *11, no data; 12, Monmouth Co. (Knieskern and Cleburne); 13–15, Vincentown (Bryan); *16, near Crawford's Corner; *17, Shark R.; *18, one mile southwest of Farmingdale.

centown 25 (T. M. Bryan); Blackwoodstown in Camden County 2 (W. Collins); Mullica Hill in Gloucester County 3 (Abbott); Allowaystown in Salem County 1 (H. C. Yarrow).

In the collection of the Geological Survey are the following teeth: Marl at Shark River 1, Manasquan marl 1 mile south of Farmingdale 2, somewhat fragmentary; Monmouth County 12 (Knieskern), and middle marl (Manasquan) at Riddleton 2 fragments (Hackett's pits). [From the above enumeration of localities the fragments of specimens apparently have been derived from the Merchantville or Woodbury clay (Crosswicks), Navesink marl (Mullica Hill), Navesink-Hornerstown marl (Blackwood and Riddleton), Manasquan marl (Farmingdale) and the Miocene (Allowaystown) K.]

OTODUS LEVIS Gibbes.

Otodus levis Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199, Pl. 26, fig. 141 (type). (New Jersey.)

Known only from the record of Gibbes from within the limits of the State. He says: "I have since seen one in the cabinet of the Academy from New Jersey." I cannot find that his figures

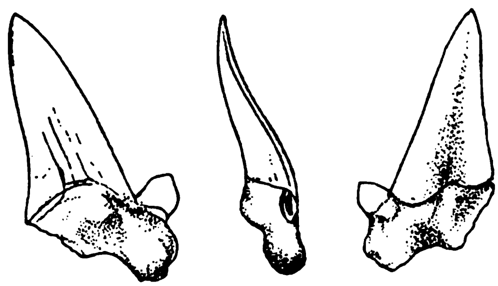

FIG. 22.—*Otodus levis* Gibbes. (From Gibbes.)

differ from those I give as *Otodus appendiculatus,* except that he shows the crown deflected and more elongate.

Formation and locality.. This species has been ascribed to the Eocene, but no special locality within the State has been given by Gibbes. It was originally obtained in the same formation of South Carolina.

OTODUS LANCEOLATUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 5. *New Jersey.*

Lamna lanceolata (Agassiz) Morton, Am. Journ. Sci. Art., 1835, p. 277 (name only, based on preceding).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 1. *Arenaceous beds of New Jersey.*

Lamna obliqua (Agassiz) Morton, Journ. Acad. Nat. Sci. Phila., VIII, 1842, p. 15 (name only, based on preceding).

Otodus obliquus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199. figs. 131–137. (New Jersey Eocene casts.)

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236. (Vincentown.)

Teeth robust, usually elongated as an isoceles triangle, and rather thick. Coronal surface but slightly compressed, attenuated,

sharply pointed, and faces convex in varying degrees, but usually outer less so. Occasionally distinct vertical plications on outer coronal face. Apex usually erect, seldom deflected much. Cutting-edges mostly entire, or only occasionally in small examples with a few obsolete serrations near base. Usually one cusp basally on each side, often large, and edges entire. Rarely still a second smaller basal external cusp. Root robust, thick, outer face usually flattened, and inner face swelling in a large convexity. In profile lower margin of root emarginated to crescentic, and ends not much produced. Teeth reach 84 mm. in length.

This appears to be rather variable. Some writers think certain teeth ascribed to it may belong to *Carcharodon*, as in rare instances their edges show the faint serrations alluded to above. Though known only from detached teeth, this species would evidently have obtained some size, being very likely an all-sufficient predatory monster. The teeth are among the most abundant of all the sharks' teeth found in the fossil beds in the State. Unfortunately Morton's *Lamna lanceolata* is the oldest name available for this species, having virtually several years priority over the familiar *Otodus obliquus* Agassiz.

Formation and locality. I have examined many series of specimens in the collections of the Academy, most of which are without detailed data. New Jersey 5 (Burtt), 1 (C. Budd), 1 (J. P. Wetherill), 1 (B. Coates), 14 (C. C. Abbott), 5 (E. D. Cope); Monmouth County 12 (J. H. Slack, J. Parke. J. H. Powell, Jr., Abbott), 1 (Powell), 1 (Abbott), 2 (Slack), 15 (W. Cleburne), 1 (Burtt); Farmingdale 12 (H. A. Pilsbry in 1892); Shark River 1 (P. D. Knieskern); Long Branch 1, no donor, 1 (H. C. Chapman); Burlington County 3 (C. Budd), 39 (T. A. Conrad); Vincentown 84 (T. M. Bryan), 21 (Bryan on May 4th, 1875) from greensand, 1 (G. Bryan), 1 (C. B. Barrett); Pemberton 7 (C. Budd); Pointville 2 (W. F. Atlee in December, 1863); Fostertown 1 (H. N. Potts); Medford 6 (L. Woolman); Allowaystown in Salem County 1 (H. C. Yarrow).

In the collection of the Geological Survey are the following: Monmouth County 2 (P. D. Knieskern), upper marl of Far-

mingdale 2 (Johnson's pits), upper marl of Shark River 1 (A Shafter's pits), Shiloh 16 (E. Davis), marl of Shark River 1 without donor, Manasquan marl 1 mile south of Farmingdale 6, somewhat fragmentary; upper marl at Poplar 1; Vincentown Cretaceous 1 (Dr. Brown); upper marl of Vincentown 1 (Dick's pit), and 14 without data.

[The material from the above localities, so far as any reference can be made, apparently came from the Manasquan marl, the Shark River marl and the Shiloh marl, *i. e.*, from the top of the Cretaceous, the Eocene and the Miocene, K.]

Genus CARCHARODON Müller and Henle.

Carcharodon (Smith) Müller and Henle, Arch. Naturg., 1838, p. 84. Type *Carcharodon verus* Agassiz, virtually monotypic.

Teeth large, flat, erect, regularly triangular, edges serrated. Spiracles minute or absent. First dorsal moderate, nearly midway between pectorals and ventrals. Second dorsal and anal very small. Caudal peduncle rather stout, lobes of lunate fin not very unequal. Pectorals large. Ventrals small.

Large pelagic fishes found in most all warm seas and reputed the strongest and most voracious of all fishes. The fossils embraced in this genus represent the remains of species many times larger, and thus far more formidable than those existing, or the so-called "man-eaters." It is possibly the sole survivor of about 19 described extinct species, all of which are only known from detached teeth.

CARCHARODON AURICULATUS (Blainville).

Squalus sp. Morton, Syn. Org. Rem. Cret. U. S., 1834, p. 16, Pl. 12, figs. 3 and 5. *New Jersey.*

Carcharias canceolatus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on above and impr. err.).

Carcharias lanceolatus (Agassiz) Morton, Journ. Acad. Nat. Sci. Phila., VIII, 1842, p. 16 (name only, based on above).

Squalus sp. Morton, Syn. Org. Rem. Cret. U. S., 1834, p. 16, Pl. 12, fig. 4. *New Jersey.*
Carcharias megalotis (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).
Carcharodon acutidens Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1848, p. 146, figs. 39-44. (New Jersey.)
Carcharodon angustidens Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand of No. 5, New Jersey.)
Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)
Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236. (Vincentown.)

Teeth comparatively narrow, robust, thickened and compressed. Coronal surface variably convex, though outer usually slightly more or less flattened. Apex often decidedly acuminate and deflected to one side. Cutting-edges usually coarsely serrated, the serræ often individually variable, and always graduated small towards tip of apex. Usually a broad basal cusp on each side, sometimes a second, and serrations in its cutting-edge usually enlarged. Tips of most all serratures rounded. Root variable, usually robust, outer face flattened concavely, and inner face often swelling in a large median bulge. In profile lower margin of root often evenly emarginate to crescentic, though ends not especially produced. Teeth reach 112 mm.

This is quite variable and shows many variations in the teeth. Some examples from the Maryland Miocene and others from Monmouth County, N. J., approach *Carcharodon polygurus,* but have the basal lateral cusps but slightly differentiated. Besides detached teeth this species is known from two nearly complete skeletons from near Antwerp in Belgium.

Formation and locality. I have examined a series of examples from the State now in the Academy, all detached teeth. Monmouth County 10 (P. D. Knieskern), 1 (Grier), 1 (C. C. Abbott); Deal 2 (C. Breed), 4 (W. G. Budd); Shark River 1 without donor, 3 (Knieskern), 2 from the Miocene (T. A. Conrad); Long Branch 2 (H. C. Chapman); Farmingdale (H. A. Pilsbry in 1892); Trenton Falls [Tinton Falls ? K.] (Abbott); Burlington County 1 (Abbott), 16 (Conrad), 7 (C. Budd), 2 (J. P. Wetherill), 4 (E. Hallowell); Pemberton 3 (C. Budd), 1 (T. M. Bryan); Vincentown 17 (C. B. Barrett), from the

greensand 115 (Bryan); Mullica Hill in Gloucester County 1 (Abbott); Cumberland County 1 (T. B. Gillette). The following labeled simply "New Jersey" are: 1 (Coates), 1 (Budd), 1 (Wetherill), 2 (Chaloner), 3 (Abbott), 1 (W. Cleburne), 4 without donor.

In the Geological Survey collection are the following teeth: Monmouth County 6 (Knieskern); Shiloh 9 (E. Davis); Vincentown Cretaceous 2 (Dr. Brown), and 3 without data. [The formations apparently represented are the Navesink-Hornerstown bed, the Manasquan marl, Shark River marl and the Shiloh marl, *i. e.*, Cretaceous, Eocene, Miocene beds, K.]

CARCHARODON POLYGURUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 12, fig. 2. "Found in both the arenaceous and calcareous strata" [the former evidently with reference to *New Jersey*].

Carcharias polygurus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).

Carcharodon megalodon Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Teeth comparatively broad, compressed and not especially thick. Coronal surface moderately convex, outer somewhat flattened. Apex slightly deflected to one side. Cutting-edges serrated, more distinct mostly in smaller examples, and then small. No basal cusps. Tips of serratures rounded. Root compressed, outer face flattened, and inner face rather evenly though usually moderately convex. In profile lower margin of root forms emargination often at an obtuse angle, or moderately crescentic. Ends of roots usually compressed and about as broad as rest of basal portion. Teeth range from 40 to 133 mm. in length.

This species seems to be known only from the large detached teeth. These are often with their edges so worn that the marginal serræ appear obsolete or in some cases to be absent. Probably the largest of all fishes, it having been estimated to have reached a length of over twice that of the largest known existing fish, *Cetorhinus maximus*, or nearly three times that of its nearest existing relative, *Carcharodon carcharias*. Bowerbank estimated the length of *Carcharodon megalodon* to be about 87

feet 7 inches. Its distribution through most all Tertiary seas must have rendered incessant the butchery of the majority of other acquatic animals. Smaller teeth of this species from the Maryland Miocene have their edges finely serrated, one showing traces of an imperfect or very obsolete basal cusp. Altogether, except some of Yarrow's examples, the entire series of New Jersey teeth examined differ little from Agassiz's figures, except in having the serrations along the cutting-edges worn.

Carcharias polygurus Morton seems to be the oldest available name for this species, and must, therefore, be adopted, *C. megalodon* Charlesworth, the name now widely adopted, not appearing until the following year.

Formation and locality. I have examined the following teeth from the Tertiary marls: Monmouth County 1 without donor, 1 (Grier); Shark River 2 (P. D. Knieskern); Burlington County 1 (T. A. Conrad); Vincentown 5 (T. M. Bryan); Atlantic City in Atlantic County 1 (E. Lippincott); Alloway stown in Salem County 3 fragments (H. C. Yarrow); "New Jersey" 1 (Spachman), 2 (J. P. Wetherill), 1 (G. Watson); "Delaware Bay" 1 (Corse), 1 (C. C. Abbott). I also have seen an example from Delaware (P. Uhler).

In the Geological Survey collection are 4 teeth without data. [The formations represented are apparently the Manasquan, Shark River and perhaps the Miocene, K.]

Genus CORAX Agassiz.

Corax Agassiz, Poiss. Foss., III, 1843, p. 224. Type *Galeus pristodontus* Agassiz, first species, restricted by Woodward, Cat. Foss. F. Brit. Mus., I, 1889, p. 423.

Teeth compressed, more or less triangular, usually with distinct marginal serrations. In external form very suggestive of teeth or *Sphyrna* or *Eulamia*, but differing in the absence of an internal cavity.

An imperfectly definable genus, comprising extinct species of small or moderate size, known only by the teeth. About 11 species have been described.

Corax falcatus Agassiz.

Galeocerdo falcatus Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand of New Jersey.)

Teeth moderately broad, greatly compressed, and moderately high. Crown moderately oblique to nearly erect, high, smooth, broad and greatly compressed. Outer coronal surface usually flattened or but slightly convex. Inner coronal surface convex. Apex slightly deflected, broad, compressed. Cutting-edges with feeble serrations, or almost smooth. No basal cusps. Root moderately broad, deep, compressed, inner surface depressed or slightly concave and outer surface moderately convex, not bulging much. Lower margin emarginate. Length 20 mm.

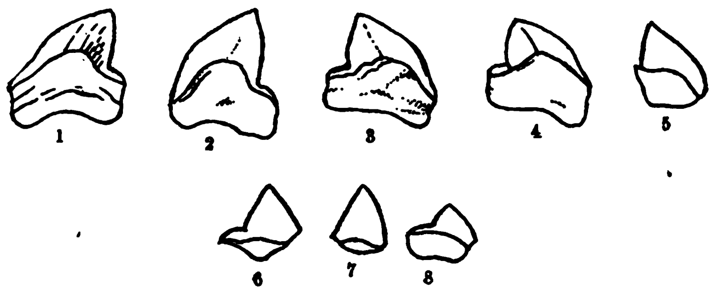

Fig. 28.—*Corax falcatus* Agassiz. 1–4, New Jersey (Kilvington); 5, Monmouth Co. (Knieskern); 6, Mullica Hill (Abbott); 7–8, Pemberton (Bryan).

This is a smaller species than the next, which it closely resembles.

Formation and locality. The following from the Cretaceous, without data as to the beds, seem to belong to this species: "New Jersey" 5 (Kilvington); Monmouth County 1 (P. D. Knieskern); Pemberton in Burlington County 2 (T. M. Bryan); Mullica Hill in Gloucester County 1 (C. C. Abbott). [The formations are probably the Navesink-Hornerstown marl and the Manasquan marl, K.]

CORAX PRISTODONTUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31. Pl. 11, fig. 6. *No locality.*

Galeus pristodontus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on above).

Galeocerdo pristodontus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 162, fig. 70. (Burlington Cretaceous.)
Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand of No. 5, New Jersey.)

Teeth broad, greatly compressed, and nearly wide as high. Crown greatly oblique to sometimes erect, low, and greatly compressed. Outer coronal surface usually flattened, or usually considerably less convex than inner surface, and sometimes a few basal vertical wrinkles. Latter with surface evenly convex. Apex often deflected, especially in lateral teeth. Cutting-edges finely and entirely serrated. Basal cusp sometimes present, low, broad, lateral, variable. Root very broad, deep, usually deeper than crown, compressed, surfaces slightly convex or inner flattened and sloping down below trenchant, so that lower profile is slightly emarginate. Ends of roots blunt, not produced. The lateral teeth seem to differ only in having their apices deflected to one side. Length reaches 30 mm.

This species appears closely allied with *Corax falcatus,* if not scarcely distinguishable by its less inclined lateral teeth and larger size. The example recorded by Cope as *Galeocerdo appendiculatus* from the Maryland Miocene agrees largely with figures 16 and 17 of *Corax appendiculatus* Agassiz. The latter has been suggested by Woodward to be the hinder teeth of either *Corax pristodontus* or *Corax affinis*. Eastman says[1] "what species is meant by his citation[2] in the same place of the *nomen nudum 'Galeocerdo appendiculatus Ag.,'* cannot now be even conjectured, as there are no specimens in the collection bearing that designation." *Galeocerdo appendiculatus* Cope is not a *nonum nudum,* but the apparently wrong allocation of *Corax appendiculatus* in the genus *Galeocerdo,* as may be attested by an examination of the single specimen in the Thomas collection labeled in

[1] Md. Geol. Surv. Miocene, 1904, p. 90.
[2] Cope, Proc. Acad. Nat. Sci. Phila., 1867, p. 141.

Cope's own handwriting (see Fig. 29, No. 23). I might add that Morton's name is the earliest available for this species.

Formation and locality. I have examined the following teeth in the Academy's collection: "New Jersey" 1 from the greensand without data and 3 from the Cretaceous; Monmouth

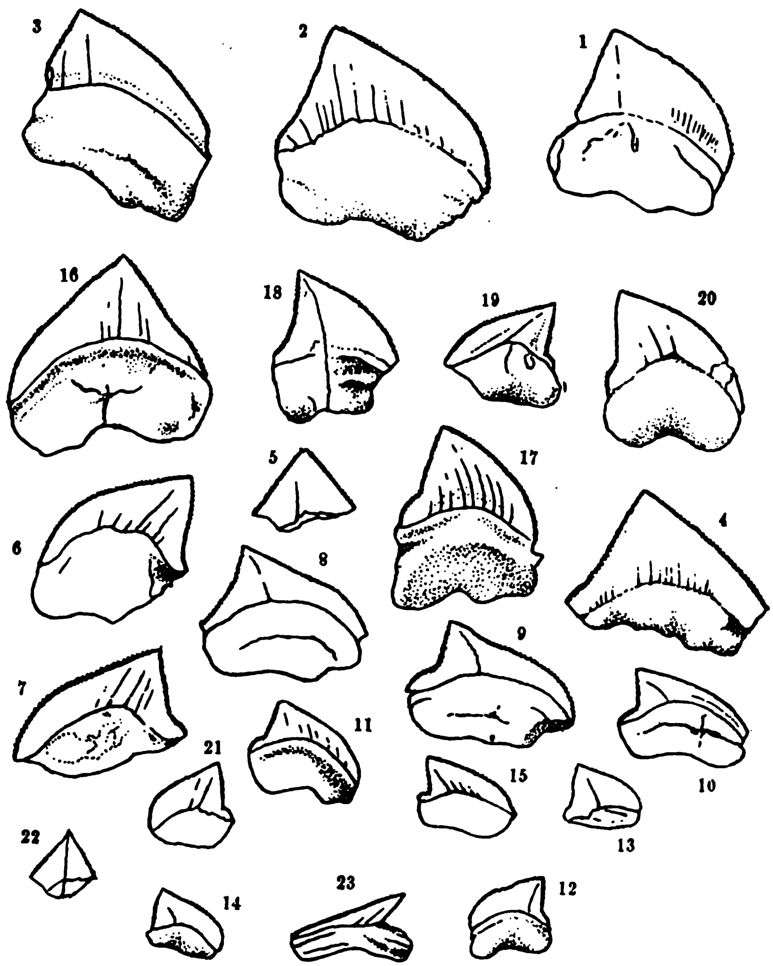

FIG. 29.—*Corax pristodontus* (Morton). *1, no data; 2–5, New Jersey; 6–14, Monmouth Co. (Slack); 15, Crosswicks (Gabb); 16–17, Vincentown (Bryan); 18–20, Pemberton (Budd); 21, Mullica Hill (Abbott); *22, one mile southeast of Crawford's Corner in Wenonah sand (J. Longstreet); 23, Charles Co., Md. (Thomas).

County 1 (C. C. Abbott), 8 (J. H. Slack); Crosswicks in Mercer County 1 (W. M. Gabb); Vincentown 2 (T. M. Bryan on May 4th, 1875), 2 (Bryan); Pemberton 3 (Bryan), 1 (C. Budd); Mullica Hill in Gloucester County 1 (Abbott).

In the Geological Survey collection I found the following: Monmouth County 1 (P. D. Knieskern) and a fragmentary crown from the Wenonah sand a little less than 1 mile southeast of Crawford's Corner (J. Longstreet's pit). [The formations represented are the Merchantville or Woodbury clay, the Wenonah sand, the Navesink-Hornerstown marl and the Manasquan marl, K.]

Family GALEORHINIDÆ.

THE REQUIEM SHARKS.

Body elongate. Head normal. Snout longitudinally and normally produced. Eyes with nictitating membranes. Gill-openings moderate, last above pectoral base. Spiracles small or obsolete. Oviparous. Dorsals 2, first high, short and entirely before ventrals. Second dorsal comparatively small, opposite anal. Tail mostly bent up from base of caudal fin, and sides without keel. Fins without spines.

This is the largest group of recent sharks, and with many closely related forms, difficult of determination, is found living in most all seas. The living forms comprise about 20 genera, and only to a few of them have fossils been referred. Also, two extinct genera have been described.

Genus GALEOCERDO Müller and Henle.

Galeocerdo Müller and Henle, Syst. Besch. Plag., 1838, p. 59. Type *Galeocerdo tigrinus* Müller and Henle, first species, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, p. 402.

Galeodes Heckel, Sitz. Ak. Wiss. Wien, XI, 1853, p. 324. Type *Galeodes priscus* Heckel, monotypic.

Boreogaleus Gill, l. c.[1] Type *Squalus arcticus* Faber, specified, montoype.

Mouth crescent-shaped. Teeth similar in both jaws, large, oblique, coarsely serrated on both margins and with deep notch

[1] See diagnosis, p. 411.

on outer margin. Spiracles present. First dorsal opposite space between pectorals and ventrals. Caudal with double notch. Pit on tail above and below at caudal base.

Among existing species large sharks in most seas, referred to about four species. About 30 fossil species have been described.

Galeocerdo aduncus Agassiz.

Galeocerdo aduncus Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Teeth compressed, broad, elevated, and rather thin. Coronal surfaces rather low, compressed, smooth, broad, pointed, and inner slightly more convex than outer, which is somewhat flattened in most cases. Apex usually deflected greatly to one side, and longer coronal margin mostly forming a very obtuse angle, sometimes nearly evenly convex. Cutting-edges finely serrated. Margin below notch with graduated serræ, those at notch largest, and generally at least four more conspicuous. No basal cusps. Root broad, compressed, deep internally and moderately convex, and externally rather concave and shallow. Lower margin usually moderately emarginate. Length 18 mm.

This species seems to be close to *Galeocerdo contortus,* and appears to differ chiefly in the coronal apex of the teeth, being flatly compressed and broad. According to Woodward, it closely resembles the living *Galeocerdo arcticus* in the dentition, but the teeth are smaller. I have identified the material here listed to some extent provisionally.

Formation and location. Known from upper Cretaceous and Miocene, where most likely the following were obtained: "New Jersey" 2 (Burtt); Monmouth County 3 (P. D. Knieskern), 3 (W. Cleburne); Deal 1 (W. A. Powell); Shark River Miocene 3 (T. A. Conrad); Burlington County 4 (Conrad); Vincentown 2 (T. M. Bryan); Allowaystown in Salem County 1 without donor.

In the Geological Survey collection is a single tooth from the middle marl of Riddleton (Hackett's pits). [From the above

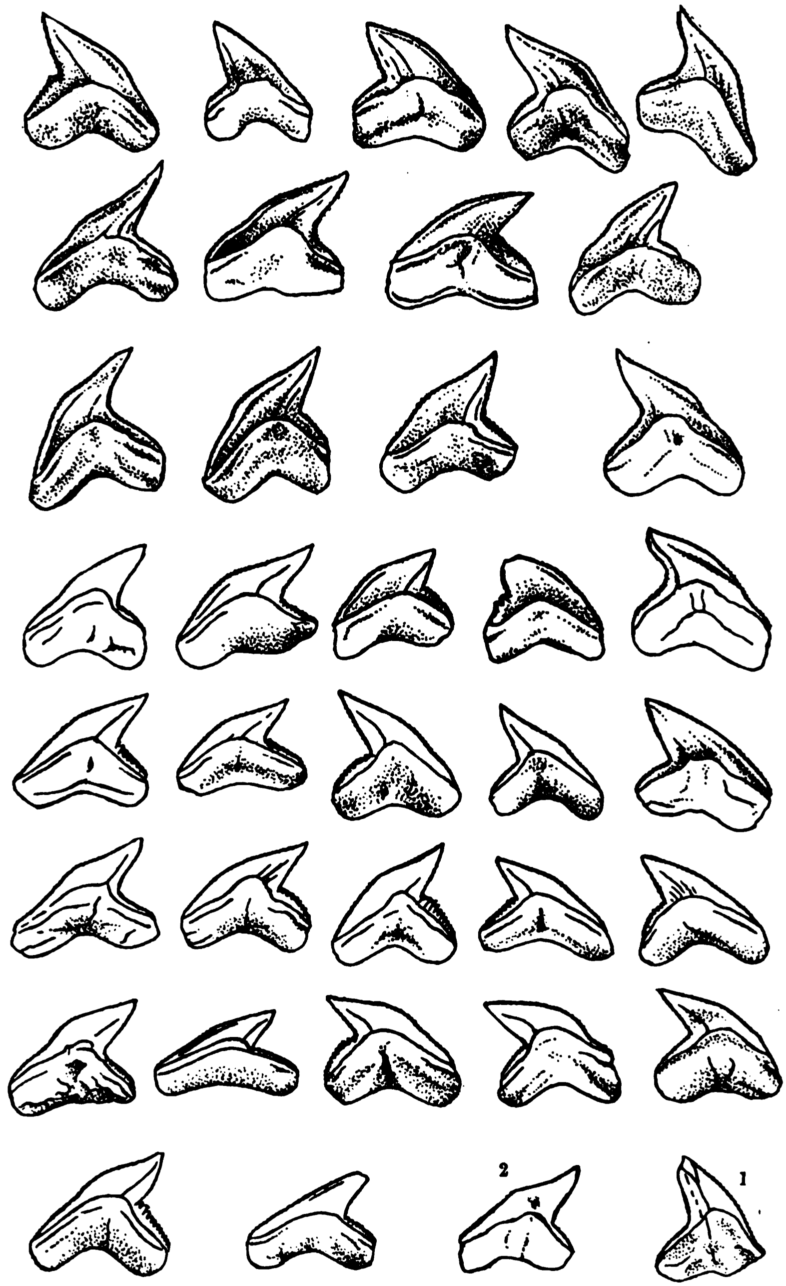

FIG. 30.—*Galeocerdo aduncus* Agassiz. 1, Monmouth Co. (Abbott); *2, Riddleton (Hackett), and others from Charles Co., Md. (Thomas).

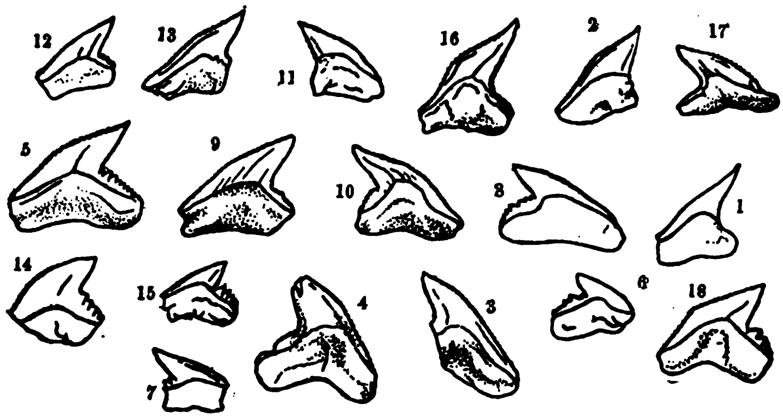

FIG. 31.—*Galeocerdo aduncus* Agassiz. 1–3, Monmouth Co. (Cleburne); 4–5, Monmouth Co. (Abbott); 6, Monmouth Co. (Knieskern); 7, Deal (Powell); 8–10, Burlington Co. (Conrad); 11–15, Vincentown (Bryan); 16–18, Allowaystown (Yarrow).

record the geologic formations are inferred to be the Navesink-Hornerstown marl, the Manasquan marl and the Kirkwood clay (Shark River Miocene) K.]

GALEOCERDO CONTORTUS Gibbes.

Teeth robust, well elevated, little compressed. Coronal surface well convex, high, and sharply pointed. Inner coronal surface, though evenly convex, scarcely more so than outer, which

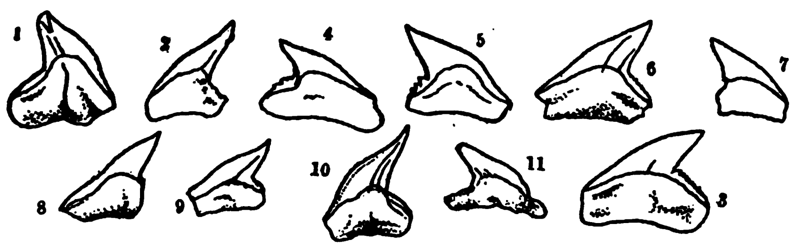

FIG. 32.—*Galeocerdo contortus* Gibbes. 1, Monmouth Co. (Abbott); 2, Monmouth Co. (Cleburne); 3, Monmouth Co. (Knieskern); 4–6, Burlington Co. (Conrad); 7–9, Vincentown (Bryan); 10–11, Allowaystown (Yarrow).

is more or less flattened basally. Apex elongated, slender or attenuated, usually well twisted, and deflected laterally. Longer

coronal margin usually a little undulated. Cutting-edges all finely serrated, margin below notch usually with slightly enlarged serræ, graduated externally. No basal cusps. Root robust, thick, outer surface depressed to slightly concave, and inner bulging convexly and extending high. Lower margin of root emarginate. Length 24 mm.

This species does not appear to have ever been recorded from New Jersey before.

Formation and locality. A plentiful species in the Maryland Miocene, and the following, except the last, are probably from the upper Cretaceous: Monmouth County 2 (C. C. Abbott), 3 (W. Cleburne), 2 (P. D. Knieskern) and 1 without donor; Burlington County 3 (T. A. Conrad); Vincentown [Manasquan marl, K.] 3 (T. M. Bryan); Allowaystown in Salem County 2 (H. C. Yarrow).

GALEOCERDO LATIDENS Agassiz.

Teeth very broad, well compressed, low, and rather thin. Coronal surfaces low, well compressed, smooth, moderately broad, pointed, outer somewhat depressed or flattened and not

FIG. 33.—*Galeocerdo latidens* Agassiz. Allowaystown (Yarrow).

quite so convex as inner. Apex usually well deflected to one side, and longer coronal margin usually rather evenly convex. Cutting-edges finely serrated. Margin below notch with graduated serræ, those at notch largest, generally several rather conspicuous. No basal cusps. Root very broad in proportion, well compressed, not very deep, outer surface a little concave and inner a little convex. Length 18 mm.

This species closely resembles *Galeocerdo aduncus* and may be distinguished with difficulty. The only conspicuous character

appears to be the broader base with the lower crown. It has not before been reported from New Jersey.

Formation and locality. I have eight teeth from near Allowaystown in Salem County, probably from the Miocene beds (H. C. Yarrow).

Genus HEMIPRISTIS Agassiz.

Hemipristis Agassiz, Poiss. Foss., III, 1843, pp. 237, 302. Type *Hemipristis serra* Agassiz, first species, restricted by Woodward, Cat. Foss. Fish. Brit. Mus., I, 1889, p. 450.

Dirrhizodon Klunzinger, Verh. Z. B. Ges. Wien., XXI, 1871, p. 664. Type *Dirrhizodon elongatus* Klunzinger, monotypic.

Body elongated. Teeth elevated, triangular, mostly curved or inclined backward towards apex, both coronal edges becoming coarsely serrated. Root divided with two divergent branches. Upper teeth relatively large, broad, flat. Front lower teeth slender, subulate, curved inward, without denticles or only one or two minute basal points. Gill-openings wide. First dorsal close behind pectoral base. Second dorsal over anal. Caudal with upper lobe much longer, notched near end.

A single living species in the Red Sea, and seven extinct species have been described.

Hemipristis serra Agassiz.

Hemipristis serra Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lateral teeth broadly triangular, well compressed, and with moderate thickness. Crown elevated, well compressed, falcate, surfaces convex, but outer slightly flattened, and smooth. Sometimes a few short basal wrinkles vertically on outer surface. Cutting-edges strongly serrated, serræ becoming slightly enlarged, or remaining subequal in size well on apex, though not extending to its tip. Apex usually strongly deflected laterally, usually inner serræ more numerous and much smaller than those on external edge. Often surfaces of crown are slightly twisted or undulated in places, giving quite irregular profiles. No basal cusps. Root well compressed, inner surface often flattened or

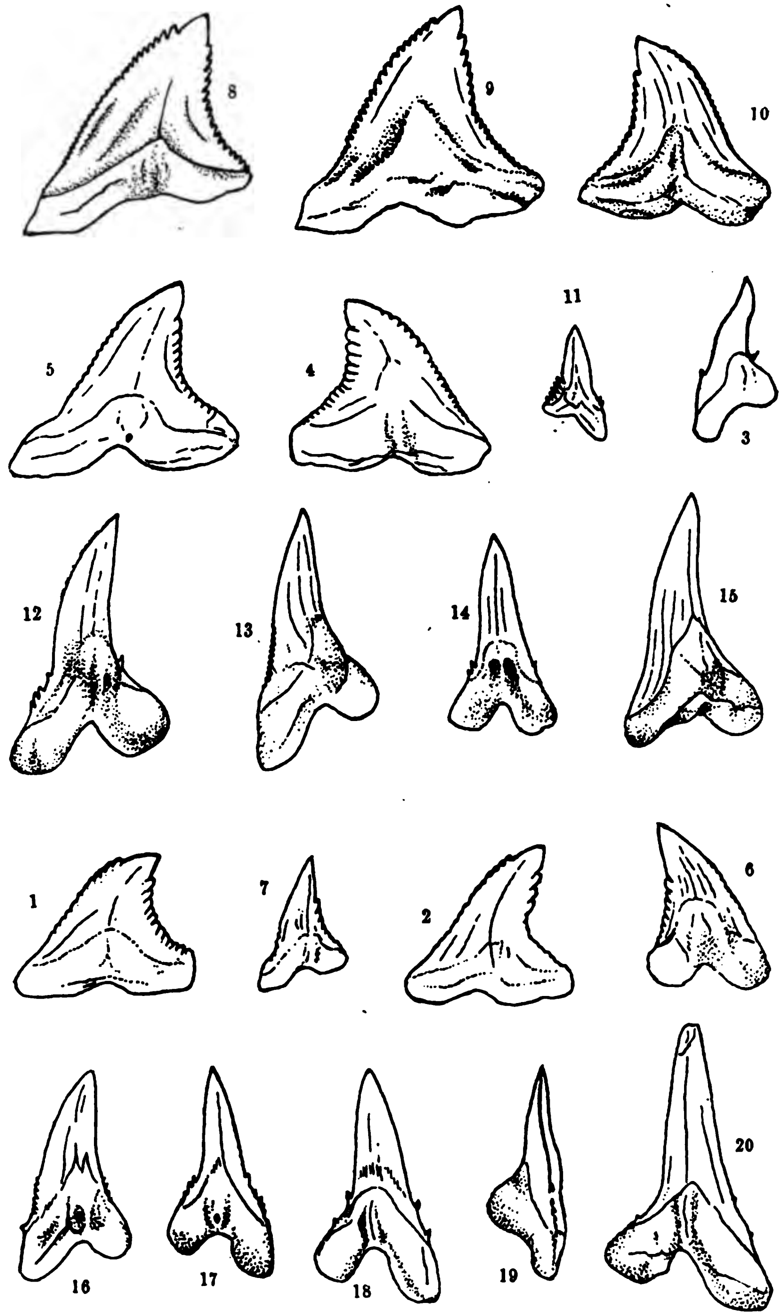

FIG. 34.—*Hemipristis serra* Agassiz. 1–2, Pemberton (Bryan); *3, Vincentown (Dick); 4–5, Salem Co. (Uhler); 6–7, Allowaystown (Yarrow); 8–20, Charles Co., Md. (Thomas).

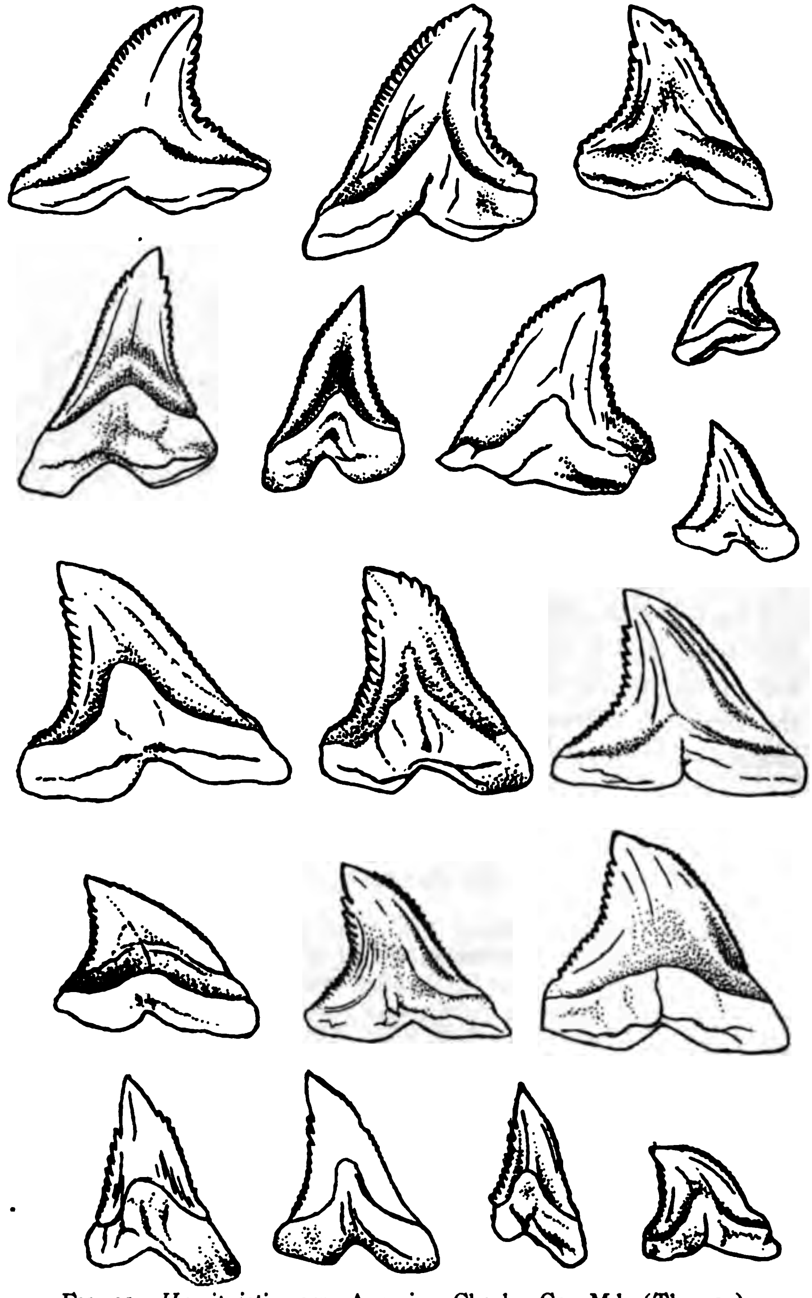

FIG. 35.—*Hemipristis serra* Agassiz. Charles Co., Md. (Thomas).

concave, and outer moderately convex. Ends of root widely diverging, and lower edge usually a little emarginated medianly. Cutting-edges of lower front teeth very sharp or blade-like along each edge of crown for apical half. These teeth also differ in often having no serratures, and others show one to twelve basally. They also have a very swollen or protruding inner base, frequently with a median sulcus, and the ends of the root are often markedly unequal. Length reaches 4 cm.

This is a strongly marked form, and only the median slender lower teeth somewhat suggest *Isurus* or *Lamna*, but are much thicker. Most all of Agassiz's figures agree with my material.

Formation and locality. I have examined the following from New Jersey: Monmouth County 11 (P. D. Knieskern); Long Branch 1 without donor; Pemberton 2 (T. M. Bryan) and Vincentown 1 (Bryan) in Burlington County; Mullica Hill in Gloucester County 1 (W. M. Gabb); Allowaystown 9 (H. C. Yarrow); in Salem County 5 (P. Uhler).

I have also examined a tooth in the Geological Survey collection from Shiloh in Cumberland County (E. Davis). [From the above citation of localities the specimens are probably from the Navesink-Hornerstown marl, the Manasquan marl of Cretaceous and from the Kirkwood formation of the Miocene, K.]

Genus GLYPHIS Agassiz.

Glyphis Agassiz, Poiss. Foss., III, 1843, p. 243. Type *Glyphis hastalis* Agassiz, monotypic.

Cynocephalus (Klein) Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. 579. Type *Squalus glaucus* Linnæus, second species, virtually restricted by Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, p. 401. (Name considered inadmissible as simply a reprint, also preoccupied.)

Prionodon Müller and Henle, Syst. Besch. Plag., 1838, p. 35. Type *Squalus glaucus* Linnæus, first species. (Name preoccupied.)

Prionace Cantor, Journ. Asiat. Soc. Bengal, XVIII, 1849, p. 399. Type *Squalus glaucus* Linnæus, virtually as this name is proposed to replace *Prionodon*.

Body slender. Head rather long, slender. Teeth in both jaws strongly serrated in adult, those in upper broad and lower narrower, straight and claviform. No spiracles. Embryo not attached to uterus by a placenta. First dorsal large, inserted

midway between pectoral axils and ventrals. Second dorsal much smaller than first, usually not larger than anal.

Large, slender, swift, voracious sharks in warm seas, comprising about two existing and 27 extinct species.

GLYPHIS EGERTONI (Agassiz).

Galeocerdo egertonii Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Glyphis subulata Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 194, Pl. 25, figs. 86-87. (New Jersey Greensand, from Wetherill.)

Teeth broadly triangular, well compressed. Crown compressed, erect or moderately inclined, and notched on each margin, though posterior or external most conspicuous. Surfaces smooth, convex on inner and outer flattened, latter sometimes with a few vertical basal folds or wrinkles. Cutting-edges finely and conspicuously serrated, the serratures usually extending to the apex. Apex pointed, sometimes deflected. No basal cusps. Root compressed, outer surface depressed or concave and inner moderately convex. Ends of root widely divergent, and lower margin usually emarginate. Length about 17 mm. in larger.

The lower teeth are said to be probably narrower than the upper. The specimens I have listed all appear to belong to this species, though the differences between *Aprionodon gibbesii*, *Sphyrna prisca* and *Glyphis egertoni* are scarcely evident in some cases. The latter may, to some extent, be characterized by its broad upper teeth.

Formation and locality. The following teeth are probably from the upper Cretaceous or Miocene beds [the Navesink-Hornerstown bed marl, the Manasquan marl, the Kirkwood formations, K.], though no such information is given on any of the labels. Monmouth County 2 without donor, 2 (P. D. Knieskern), 26 (Knieskern, W. Cleburne, C. C. Abbott); Burlington County 13 (T. A. Conrad); Vincentown 15 (T. M. Bryan); Mullica Hill in Gloucester County 3 (Abbott); Allowaystown in Salem County 48 (H. C. Yarrow).

The following teeth in the collection of the Geological Survey are probably this species: Monmouth County 1 (Knieskern), 2

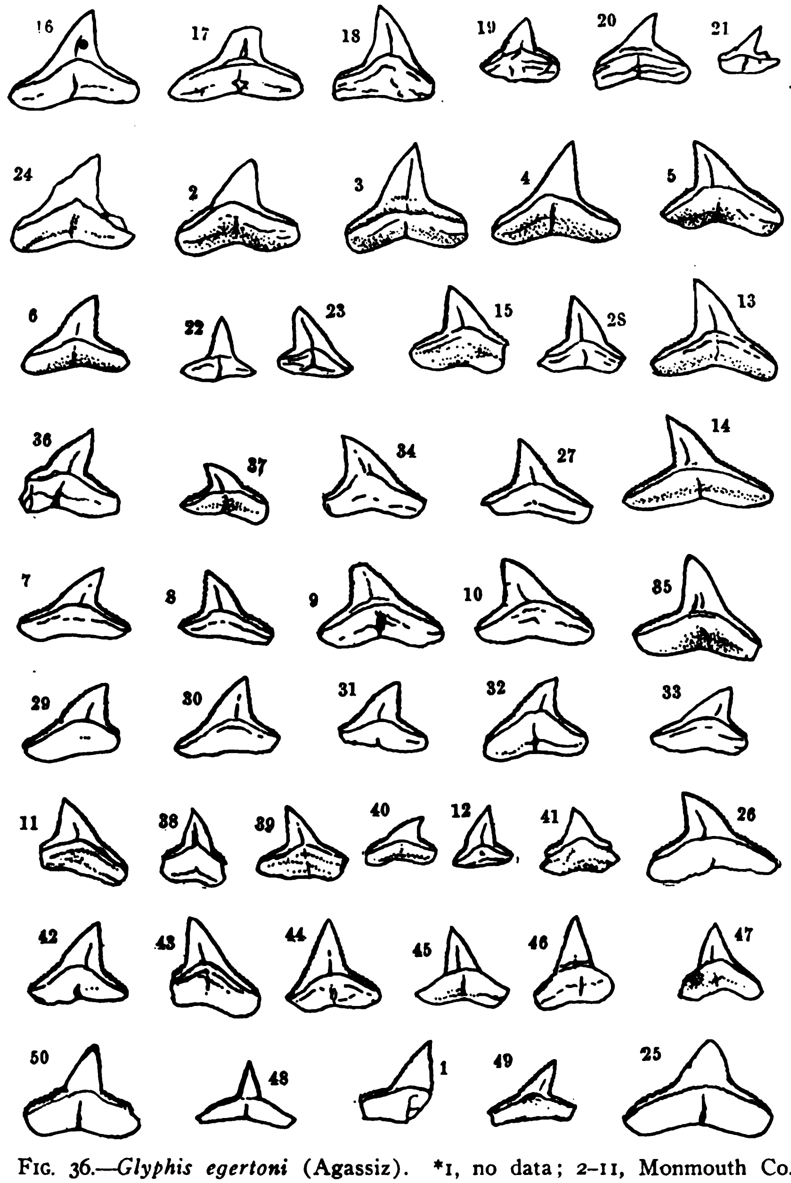

FIG. 36.—*Glyphis egertoni* (Agassiz). *1, no data; 2–11, Monmouth Co. (Knieskern, etc.); 12, Monmouth Co. (Knieskern); 13–15, Burlington Co. (Conrad); 16–24, Vincentown (Bryan); *25, Vincentown (Dick); 26, Mullica Hill (Abbott); 27–47, Allowaystown (Yarrow); *48–49, Riddleton (Hackett); *50, no data.

from the middle marl at Riddleton (Hackett's pits) and 1 without data.

Family SPHYRNIDÆ.

THE HAMMER-HEAD SHARKS.

Mouth crescent-shaped, under "hammer." Teeth in jaws similar, oblique, each with notch on outside near base. Nostrils anterior and eyes on side of "hammer." Last gill-opening over pectoral. No spiracles. First dorsal and pectorals large, and dorsals nearer pectorals than ventrals. Second dorsal and anal small. Pit at caudal root, single notch towards fin tip.

Large sharks, among living forms easily distinguished by the peculiar form of the head, which is slightly different in each species. Though a number of generic names have been proposed, they are now generally referred to the single genus *Sphyrna*.

Genus SPHYRNA Rafinesque.

Sphyrna Rafinesque, Ind. It. Sicil., 1810, pp. 46, 60. Type *Squalus zygæna* Linnæus, virtually first species, restricted by Jordan and Gilbert, Bull. U. S. Nat. Mus., 1882, p. 26.

Sphyra, auct.

Cestracion (Klein) Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. 580. Type *Squalus zygæna* Linnæus, virtually first species, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VIII, 1861, p. 37.

Sphyrnias Rafinesque, Analyse de la nature, 1815, p. —? Type *Squalus zygæna* Linnæus, virtually, as this name is offered to replace *Sphyrna* considered too short.

Cestrorhinus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 121. Type *Squalus zygæna* Linnæus, first species.

Zygæna Cuvier, Règne Animal, II, 1867, p. 27. Type *Squalus zygæna* Linnæus, first species, by tautonomy, but preoccupied in insects.

Zygana, auct.

Platysqualus Swainson, Lard. Cab. Cyclop. N. H., II, 1839, p. 318. Type *Squalus tiburo* Linnæus, monotypic.

Eusphyra Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, pp. 403, 412. Type *Zygæna blochii* Cuvier, designated, monotypic.

Reniceps Gill, l. c. Type *Squalus tiburo* Linnæus, designated, monotypic.

Characters of the genus expressed in those of the family.

About six existing species have been described, grading almost perfectly from the narrow hammer of *Sphyrna blochii* to that of

the kidney-shaped head of *Sphyrna tiburo*. The fossils are only known from detached teeth, which seem to be largely doubtfully located in this genus, owing to their close resemblance to those of *Eulamia*, and are referred to six species.

SPHYRNA GIBBESII Hay.

Teeth compressed, triangular and moderately thick. Crown moderately large, compressed, sharp-pointed, its base width about one-half its height, outer face flattened and inner evenly convex, surfaces smooth. Apex slightly deflected. Cutting-edges entire. At base of crown 3 or 4 broad-pointed cusps, graduated down externally till outer are quite small. Edges of cusps entire, though trenchant. Root rather wide, moderately thick, inner surface flattened or slightly concave, and outer surface moderately swollen convexly. Lower edge of root a little emarginate. Length 8 mm.

FIG. 37.—*Sphyrna gibbesii* Hay. Monmouth Co. (Knieskern).

My examples seem to be this species, which appears to be characterized by its small size, entire cutting-edge and enlarged basal cusps. They agree largely with Gibbes' figure of *Sphyrna denticulata*. The species has not before been recorded from New Jersey.

Formation and locality. I have six teeth from Monmouth County (P. D. Knieskern). These are without definite indication as to which of the Cretaceous beds they were found in, but presumably the upper would be correct.

SPHYRNA PRISCA Agassiz.

Zygæna prisca Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lateral teeth well compressed, with broad base, triangular. Crown small, narrowly triangular, compressed somewhat smooth, outer surface flattened and inner surface evenly convex.

Outer basal surface rarely with several short wrinkles. Apex deflected more or less laterally, slender-pointed. Cutting-edges finely serrated and serræ of about more or less even size. Lateral coronal margins long, but little less than rest of crown itself when measured to notches, and low. Serræ always more or less conspicuous on these lateral crown margins, even when obsolete or absent on coronal margin above notches. No basal cusps. Root compressed, usually wide, conspicuous, depressed or concave externally, and inside swelling slightly convex. Ends of

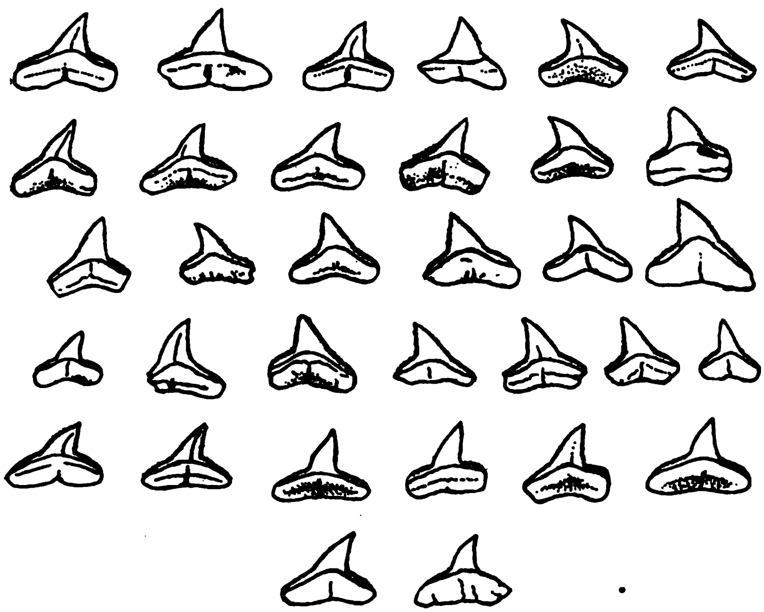

FIG. 38.—*Sphyrna prisca* Agassiz. Charles Co., Md. (Thomas).

roots widely diverging, so that lower edge is concave or at least slightly notched medianly. Length reaches 15 mm. This description from a series of examples from the Maryland Miocene.

This species is close to *Glyphis egertoni,* and possibly material identified with it may belong to that species, but, following Cope, I have allowed it all to fall with the present provisionally. The crown in most of the examples is conspicuously narrow or small, and the root is mostly very wide. Several examples with extremely wide roots suggested a new species to Cope, but they

are scarcely different in other respects. They have been called *Carcharias collata* by Eastman. I have not examined any New Jersey material.

Formation and locality. Known only by Cope's record from the Miocene of Cumberland County.

Order BATOIDEI.

THE RAYS.

Body typically disk-like, broad, flat, margin of disk usually formed by expanded pectorals. Tail comparatively slender. Gill-openings inferior, slit-like, 5 in number. Spiracles present. Vertebræ cyclospondylous, or each one with internal calcareous lamellæ not radiating, arranged in one or more concentric circles or series around central ring. Dorsal fins inserted on tail when present. No anal fin. Caudal fin small or wanting.

The extremes of specialization in this group widely depart from the typical sharks, though many intergradations render them nearly complete. As many fossils have been found, they probably evolved quite early. Except the Rajidæ, most all the members of this group are ovoviviparous.

Sub-Order SARCURA.

Tail comparatively thick, with two dorsals and a caudal fin, but no serrated caudal spine.

About four families are usually admitted, and all represented by at least a few fossils.

Family PRISTIDÆ.

THE SAW FISHES.

Body elongate, depressed. Snout saw-like, much produced, flat, armed with strong teeth on each side set at right angles to its axis. No tentacles. No nictitating membrane. Teeth in

jaws minute, obtuse. Nostrils inferior. Gill-openings moderate, inferior. Spiracles wide, behind eye. Dorsal fins large, without spines, first nearly opposite ventrals. Caudal well developed, bent upward. A fold along each side of tail. Pectorals moderate, front margin quite free and not reaching to head.

Large shark-like rays, with the disk gradually passing into the tail, found in most warm seas about sandy shores. A single existing genus, the exact batoid prototype of the Pristiophoridæ. The fossil species of this family are all provisional, being known chiefly by rostral teeth, fragments of the rostrum, detached vertebræ, etc., thus rendering the descriptions too imperfect for final determination. They have been referred to three genera, besides to the existing *Pristis*.

Genus PRISTIS Linck.

Pristis Linck, Mag. P. Naturg. Gotha, VI, 1790, p. 31. Type *Squalus pristis* Linnæus, monotypic.

Pristobatus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 121. Type *Pristis antiquorum* Latham, first species.

Pristibatis, Pristobatis, auct.

Myriosteon Gray, Proc. Zool. Soc. Lond., 1864, p. 163. Type *Myriosteon higginsi* Gray, monotypic. (Proposed as "probably indicating a new group of Echinodermata," though really based on one of the hollow cartilaginous rostral rods of Pristis.)

Pristiopsis Fowler, Proc. Acad. Nat. Sci. Phila., 1905, p. 459. Type *Pristis perrotteti* Müller and Henle, designated.

Eopristis Stromer, Beitr. Pal. Oester. Ung., XVIII, 1905, p. 52 (16). Type *Pristis (Eopristis) reinachi* Stromer, monotype.

Characters of the genus expressed in those of the family.

About eight existing species are known, and about 19 extinct species have been described.

Pristis amblodon Cope.

Pristis amblodon Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 312. *New Jersey Eocene Greensand.*

Hussakof, Bull. Amer. Mus. Nat. Hist. N. Y., XXV, 1908, p. 34, fig. 11 (types).

Rostral teeth well compressed. Front margin convex, and surface smooth. Hind margin convex and smooth. Length of smaller example (imperfect) 26 mm.

The two fragmentary examples I have, evidently of this species, both show their front and hind edges convex. Cope pointed out this character originally, adding that both edges were also curved to the tip, though one curvature greater than the other. Further,

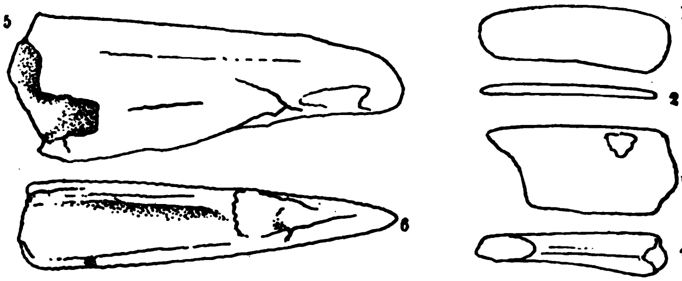

FIG. 39.—*Pristis amblodon* Cope. 1–4, Monmouth Co. (Cope); 5–6, Pemberton (Bryan).

he says the teeth are not curved out of the horizontal plane, and his example measured 32 mm.

Formation and locality. Two examples described above, rostral teeth from Monmouth County (E. D. Cope), are credited by Cope to the New Jersey Eocene.

PRISTIS CURVIDENS Leidy.

Pristis curvidens Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 414. *Near Pemberton, N. J., Greensand.*

Teeth of rostrum well compressed. Front margin evenly convex and surface smooth. Hind margin slightly concave, sometimes a little oblique on sinistral surface, and each edge distinct or a trifle trenchant or keeled. Distal edge of front margin more suddenly convex than hind margin, and convexity of former begins more distally. Teeth nearly or quite level in horizontal plane to well decurved. Length reaches 96 mm.

This species seems to be characterized chiefly by having its rostral teeth considerably curved downward. The type was about 22 cm. long.

Formation and locality. The following examples in the collection of the Academy, all rostral teeth, have been examined: Monmouth County 1 (P. D. Knieskern); Burlington County 1

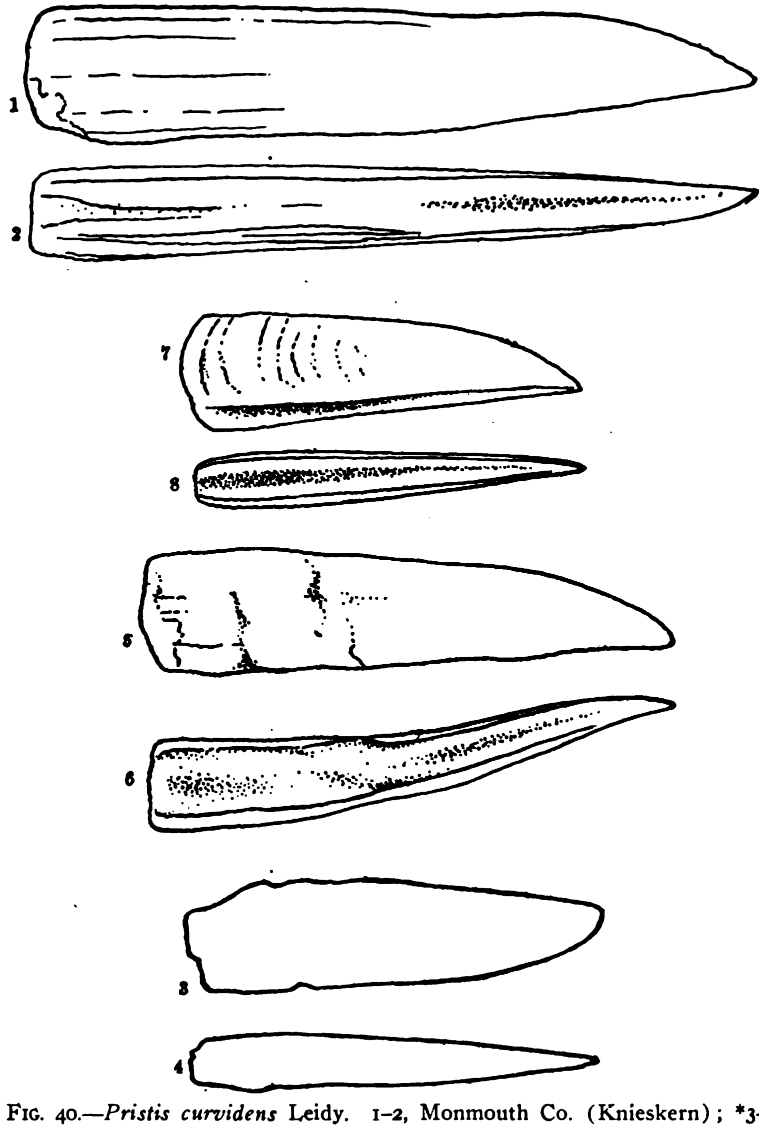

FIG. 40.—*Pristis curvidens* Leidy. 1–2, Monmouth Co. (Knieskern); *3–4, Monmouth Co. (Knieskern); 5–6, Burlington Co. (Conrad); 7–8, Vincentown (Bryan).

(T. A. Conrad); Vincentown 1 without donor and Pemberton 1 (T. M. Bryan).

I have also seen a rostral tooth in the collection of the Geological Survey without data. So far as determinable, the geologic horizon is probably the Manasquan marl.

Sub-Order MASTICURA.

Tail comparatively slender, dorsal fin single or wanting, and tail above usually armed with one or more serrated spines.

This group comprises four families, of which the *Ptychodontidæ* are entirely extinct. Of the latter *Ptychodus mammillaris* Agassiz has been ascribed to the Cretaceous of Delaware, though no representatives have been found in New Jersey.

Family MYLIOBATIDÆ.

THE EAGLE RAYS.

Disk broad. Nasal valves forming rectangular flap with posterior margin free and attached by frenum to upper jaw. Ovoviviparous. Skull less depressed than usual among rays, its surface raised so that eyes and spiracles are lateral in position. Skin smooth. Tail very long, slender, whip-like, with single dorsal near its root, behind which is usually a strong retrorsely serrated spine. Pectorals ceasing at sides of head and reappearing in front of snout as one or two cephalic fins supported by fin rays. No differentiated spines in pectorals in males, sexes similar. Ventrals not emarginate.

The existing forms large sting rays in warm seas, feeding chiefly on mollusks, which they crush with their large grinding teeth. All the known six genera are represented by extinct species, though only three of the former have persisted till the present time.

Genus MYLIOBATIS G. St. Hilaire.

Myliobatis G. St. Hilaire, Descr. Egypt, 1809, Pl. 26, fig. 1. Type *Myliobatis bovina* G. St. Hilaire, second species.

Myliobates, auct.

Ictætus Rafinesque, Analyse de la nature, 1815, p. 93 (nom nud.).

Ptychopleurus Agassiz, Poiss. Foss., III, 1838, Pl. 45, figs. 1-3. Type *Ptychacanthus faujasii* Agassiz, virtually monotypic.

Holorhinus Gill, Proc. Acad. Nat. Sci. Phila., 1862, p. 331. Type *Rhinoptera vespertilio* Girard, virtually monotype.

Bates Probst, Jahresh. Ver. Vaterl. Nuturk Württ., XXXIII, 1877, p. 88. Type *Bates spectabilis* Probst, monotypic.

Disk broad, pectoral fins not continued to snout end, ending on head sides, and reappearing on snout front as one or two cephalic fins supported by fin-rays. Tail very long, slender, whip-like, with single dorsal fin near root, behind latter usually strong retrorsely serrated spine. Nasal valves form rectangular flap, hind edge free, attached by frenum to upper jaw. Teeth hexangular, large, flat, tessellated, median usually broader than others. Skull less depressed than usual among rays, surface raised so eyes and spiracles are lateral in position. Ovoviviparous. Skin smooth, without pectoral spines, and sexes alike. Ventrals not emarginate.

The existing species, about 15, are large sting-rays feeding largely on mollusks which they crush with their large grinding teeth. They are found in most all warm seas. About 80 extinct species have been described.

Myliobatis bisulcus (Marsh).

Myliobates bisulcus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 229. *Eocene greensand of Monmouth Co., N. J.*
Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 239 (remarks).

Dental plate with central row of teeth marked along median line by a deep groove, otherwise remarkably smooth and flat. (Marsh.)

The account by Marsh is insufficient, and the species may be considered purely nominal until further elucidated. Leidy thinks *M. fastigiatus* may be the lower dental plate, in which case Marsh's name would have priority.

Formation and locality. The type was originally in the Museum of Yale College, and was from the Eocene [Shark River K.] greensand of Monmouth County.

Myliobatis fastigiatus (Leidy).

Myliobates fastigiatus Leidy, Proc. Acad. Nat. Sci. Phila., 1876, p. 86. *Monmouth Co., N. J. Eocene.* (No description).
Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 238, Pl. 31, fig. 11, Pl. 33, fig. 6 (types).
Myliobatis fastigiatus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 32 (type).

Dental plate arched in form, composed of nine median teeth and a row of about four lateral teeth on each side. Enamel surface convex, with strong median and lesser convex transverse lateral convexity, so that surface is undulated. Basal surface presents concave surface sloping each side from median range, though latter with convex surface and not sharply defined. Transverse

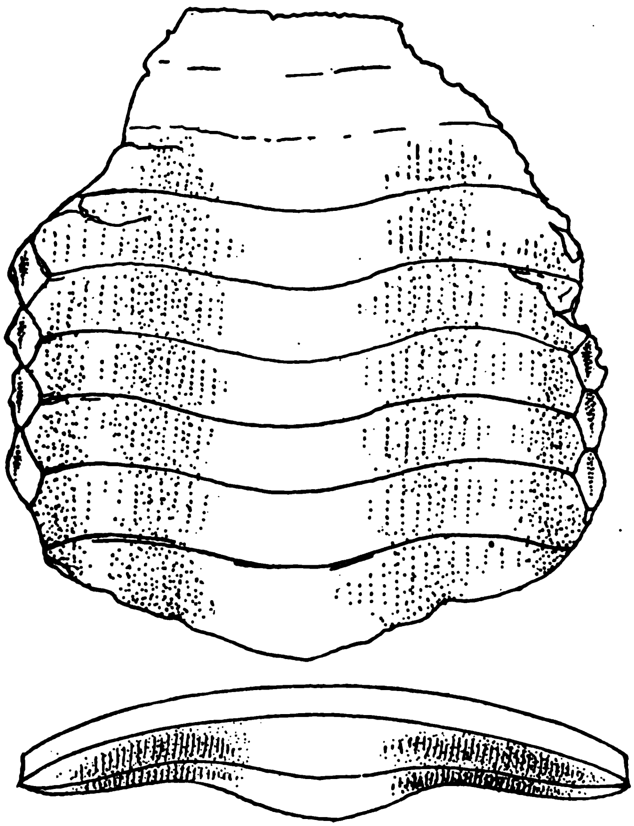

FIG. 41.—*Myliobatis fastigiatus* (Leidy). (Type.) Monmouth Co. (Cleburne).

median sutures backward in median convexity and forward on concave depressions. Vertical diameter of median teeth about one-seventh horizontal diameter, their surfaces with feeble vertical wrinkles in concave depressions and on lateral depressions, otherwise nearly smooth. Lateral small teeth rather hexagonal, horizontal diameter about three-fifths to two-thirds vertical diam-

eter, and surface of each with a depression. Length (width) 82 mm.

Known from the type described above and a paratype. Both are thought to be the upper dental plates, anteriorly abraded by the attrition of food. Leidy suggested *M. bisulcus* may possibly prove to be the lower jaw of this species, as it has a median deep groove. The other example he describes has seven large median transverse teeth in its dental plate. Although Hussakof has

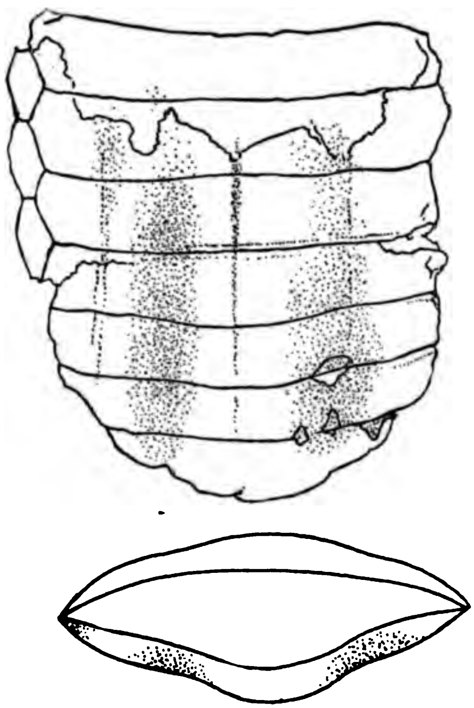

FIG. 42.—*Myliobatis fastigiatus* (Leidy). (Paratype.) Monmouth Co. (Slack).

listed an example of this species as typical and being in the American Museum in New York, the original of Leidy's figure 11 is in the Academy. Further, his example is said to be an upper dental pavement with 11 median and several small lateral teeth. Leidy states that this example has seven median teeth, together with three small teeth of the first row of one side.

Formation and locality. Known from the Eocene of Monmouth County by the type (W. Cleburne) and one paratype (J. H. Slack).

MYLIOBATIS GLOTTOIDES Cope.

Myliobatis glottoides Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 293. *Eocene bed at Farmingdale, Monmouth Co., N. J.*
Hussakof, Bull. Amer. Mus. Nat. Hist. N. Y., XXV, 1908, p. 32, fig. 8 (type).

Dental plate convex in longitudinal as well as transverse direction, composed of eight teeth, and lateral portions on either side each slightly convex, and thin off to single series of lateral teeth. On median line teeth suddenly swollen, forming together broad,

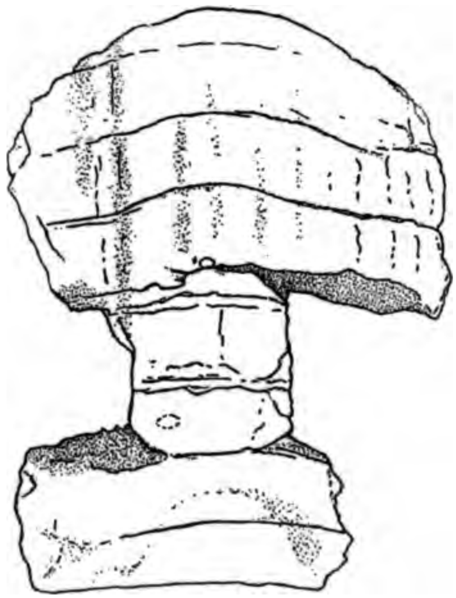

FIG. 43.—*Myliobatis glottoides* Cope. (From Hussakof.)

obtuse median ridge. Transversely each tooth is nearly straight, extremity slightly and abruptly curved backwards. Worn surface forms sub-triangular concavity. Basal surface obtusely angulate in median line below. Vertical diameter of median teeth about one-fourth horizontal diameter. Length (width) about 60 mm. (damaged). (Largely from Cope.)

Cope says this species is thick-toothed like *Myliobatis pachyodon* Cope and *Myliobatis holmesii* Agassiz, but they are not so

clearly three-ribbed in section as this one. *Myliobatis obesus* is somewhat similar, but much wider, with more curvature of teeth and biserial laterals. Each tooth is both wider (longer) and deeper than in most of the described species.

Formation and locality. Known from the Eocene [Shark River marl K.] of Farmingdale in Monmouth County. I have not examined any specimens.

MYLIOBATIS MAGISTER (Leidy).

Dental plate depressed in form, thick, composed of six median teeth, and apparently no traces of lateral teeth. Enamel surface convex, with slight median concave longitudinal depression, so

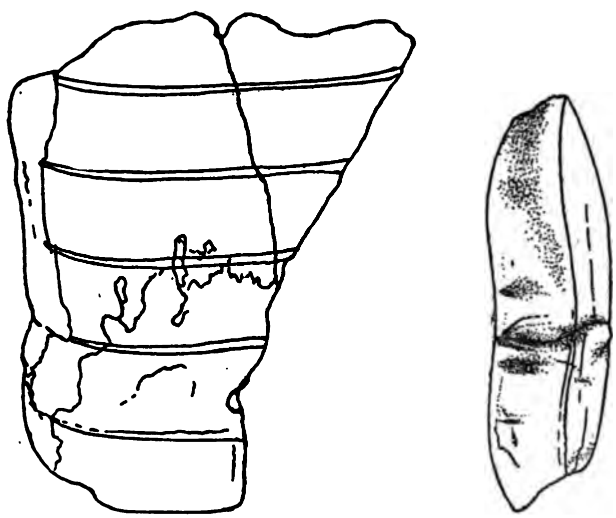

FIG. 44.—*Myliobatis magister* (Leidy). Vincentown (Bryan).

that surface is double convex with each side sloping down strongly convex. Basal surface presents convex surface sloping each side from median longitudinal convexity. Transverse median sutures nearly horizontally straight, or curving slightly posteriorly each side. Vertical diameter of median teeth about 4⅞ of horizontal diameter (imperfect) and their surfaces almost entirely smooth. Length (width) about 60 mm. (damaged).

The above-described fragment is the only example I have seen from our limits, and seems to agree with *Myliobatis magister*, which species has not been recorded before from New Jersey. It is evidently a lower dental plate. Eastman has pertinent remarks concerning this species.[1]

Formation and locality. One example from Vincentown (T. M. Bryan) from the marl [Manasquan, K.].

MYLIOBATIS JUGOSUS (Leidy).

Myliobates jugosus Leidy, Proc. Acad. Nat. Sci. Phila., 1876, p. 86. (Eocene marl beds of Burlington Co., N. J.) (No description).
Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 240, Pl. 31, figs. 4-5. *Vincentown, Burlington Co., N. J.*

Transverse tooth nearly straight, ends angular and possibly articulated with small lateral hexagonal teeth. Crown forms thick median, transversely convex prominence, with sides extended, outwardly thin. Triturating surface transversely convex on median prominence and becoming nearly flat on its reflected sides. An-

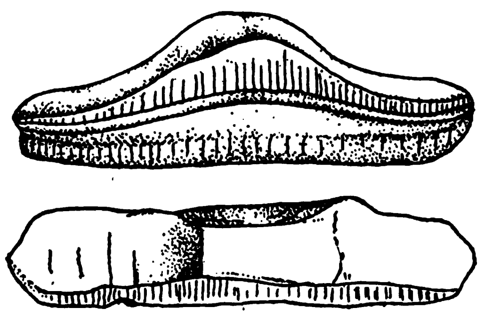

FIG. 45.—*Myliobatis jugosus* (Leidy). (From Leidy.)

terior inclining surface of crown and projecting posterior surface indicate somewhat imbricated arrangement of median teeth. Base of crown opposite median eminence concave, and this curvature at sides slightly deflected. Root straight on its attaching surface. Vertical diameter about five in horizontal diameter. Length (width) about 63 mm. (From Leidy.)

[1] Md. Geol. Surv. Eocene, 1901, p. 100, Pl. 12, fig. 3, Pl. 13, figs. 1a, 1b.

Leidy notes that the above tooth at the median prominence is no thicker than in the smaller of the dental plates described as *Myliobatis fastigiatus,* while it is considerably broader. The prominence appears as an exaggeration of the median ridge of the dental plate of *M. fastigiatus,* due to the more abrupt depression of the sides of the crown. In this specimen the coronal eminence is unsymmetrical.

Formation and locality. Only the above-described tooth, said to be from the Eocene [Manasquan ? K.] marl beds at Vincentown, in Burlington County (T. M. Bryan), and presented to the Academy of Natural Sciences of Philadelphia. I have not located this specimen.

Myliobatis leidyi Hay.

Myliobatis leidyi Hay, Amer. Nat. XXXIII, 1899, p. 785 (name based on Leidy).

Myliobates serratus (nec Meyer 1848) Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 239. *Greensand of Burlington Co., N. J.*

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 239, Pl. 32, fig. 5, (Pemberton Eocene, same example.)

Dental plate depressed in form, composed of six median teeth and a single series of lateral teeth on each side. Triturating sur-

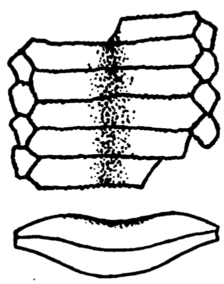

Fig. 46.—*Myliobatis leidyi* Hay. (From Leidy.)

face of plate dull, but slightly impressed along median line, inclines forward and downward on first tooth, apparently as result of wearing. Transverse sutures of median teeth gently curved with convexity backward. Lateral teeth hexagonal, nearly broad as fore and aft wide. Sutures generally, especially outer parts

of median transverse sutures and those uniting median and lateral teeth, as well as these together, remarkable for their unusually serrulate condition. Root surface slopes strongly in each side from median line. Vertical diameter of median tooth about one-sixth of horizontal. Length (width) about 27 mm. (From Leidy.)

Leidy originally identified this species with *Myliobatis serratus* Meyer, though according to Hay, as the latter was from the lower Miocene, he names Leidy's specimen *M. leidyi*. Leidy also pointed out its resemblance to the dental armature of *Myliobatis toliapicus* Agassiz and *M. suturalis* Agassiz.

Formation and locality. Known only from the above-described dental plate ascribed to the [Manasquan, K.] marl of Pemberton in Burlington County (C. H. Budd). I have not located it in the collection of the Academy, where it was originally deposited.

MYLIOBATIS RECTIDENS Cope.

Myliobatis rectidens Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 294. *Harrisonville, Gloucester Co., N. J. Miocene?*
Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 32, fig. 9 (type).

Dental plate apparently depressed in form, composed of seven median teeth and at least two series of lateral teeth each side. Median teeth entirely plane and with perfectly transverse sutures, the series very slightly convex in both directions. Vertical diameter of median teeth about five in horizontal diameter. Several of lateral teeth in inner series at least wider than long. Length (width) about 70 mm. (damaged). (Largely from Cope.)

Cope says this species resembles *Myliobatis gigas* Cope, though in the latter there are twice as many, or 12, teeth in a series of the same length and width as the present. In this species the median series are straight and in *Myliobatis gigas*[1] are recurved at the extremities.

Formation and locality. The type specimen now in the American Museum of New York seems to be the only one known. Cope

[1] Eastman identifies *Myliobatis vicomicanus* Cope with this species in Md. Geol. Surv. Miocene, 1904, p. 73, Pl. 28, figs. 3a, 3b, Pl. 29, figs. 1a, 1b.

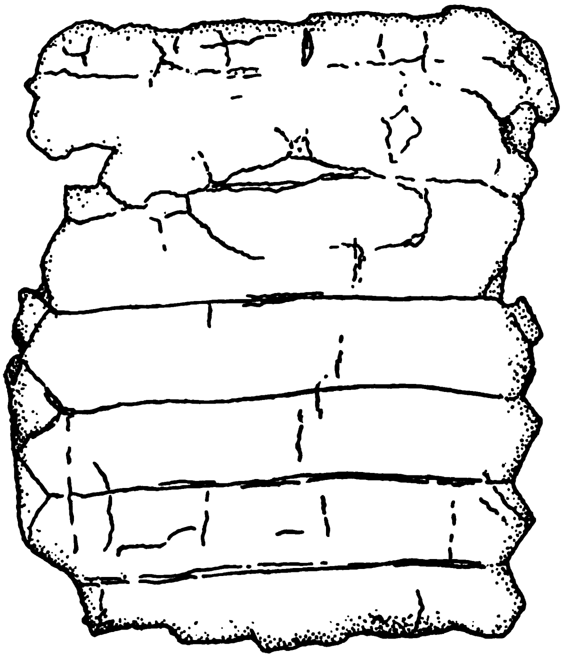

FIG. 47.—*Myliobatis rectidens* Cope. (From Hussakof.)

states it is from marl excavations at Harrisonville, Gloucester County. [These marls are now referred to the Navesink-Hornerstown bed. The Vincentown limesand also occurs here and the Miocene clay appears on the higher slopes in the neighborhood, K.] I have not seen this example.

MYLIOBATIS OBESUS (Leidy).

Myliobates obesus Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 396. *Greensand of Burlington Co., N. J.*

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236, Pl. 31, fig. 6–10, Pl. 34, fig. 44 (types of *M. rugosus* and *M. obesus*). (Pemberton and Mullica Hill.)

Myliobates rugosus (nec Meyer 1844) Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 395. *Marl of New Egypt, Ocean Co., N. J.*

Dental plate arched in form, composed of four median teeth and at least a row of lateral teeth each side. Enamel surface in general evenly convex. Basal surface convex, swelling to median longitudinal axis moderately. Transverse median sutures curve

at first slightly convex back till posterior are quite convex. Vertical diameter of median teeth about five in horizontal diameter, their surfaces with usually distinct transverse or vertical wrinkles or nearly smooth. Length (width) 59 mm.

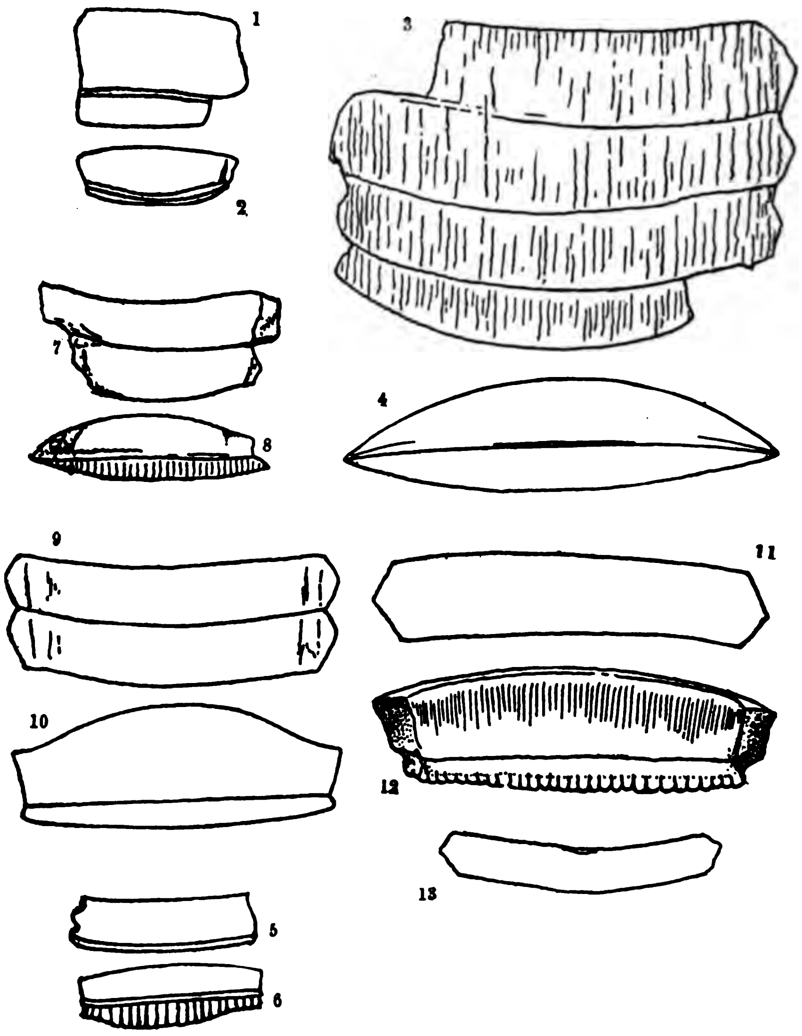

FIG. 48.—*Myliobatis obesus* (Leidy). 1–2, Monmouth Co. (Abbott); 3–4, New Egypt (Conrad) (type of *Myliobates rugosus* Leidy); *5–6, Farmingdale; 7–8, Pemberton (Budd); 9–10, Vincentown (Bryan) (type of *Myliobates obesus* Leidy); 11–13, Mullica Hill (Atkinson).

This seems to be the most abundant species found in New Jersey, and is characterized largely by its convex surface, with slightly convex striæ posteriorly.

Myliobates rugosus Leidy is preoccupied by *Myliobatis* (*Zygobatis*) *rugosus* Meyer, Neu. Jahrb., 1844, p. 335, from the lower Miocene of Weinheim, and for this reason *obesus* is retained.

Formation and locality. Known chiefly from the Cretaceous marls. I have examined the following examples: The type from New Egypt in Ocean County (T. A. Conrad); the type of *Myliobates obesus* Leidy from Vincentown (C. H. Budd), both Burlington County; 2 from Mullica Hill in Gloucester County (W. B. Atkinson). [The Hornerstown marl, the Vincentown limesand and the Manasquan marls, all Cretaceous, are the formations apparently involved, although the Miocene is known near Mullica Hill, K.]

Myliobatis kummeli sp. nov.

Dental plate depressed in form, moderately thick, composed of 17 median teeth, and at least two series of lateral teeth. Enamel surface generally slightly convex, with slight median concave longitudinal depression, so that surface is very slightly double convex, with each side sloping down somewhat strongly convex. Median depression concavely so shallow as to scarcely appear concave. Basal surface largely well and evenly convex from median axis, inclining well towards each side. Transverse median sutures posteriorly, rather evenly, though slightly convex, but anteriorly becoming somewhat slightly double convex. Vertical diameter of anterior median teeth about one-ninth of horizontal diameter, and of posterior teeth much greater. Lateral teeth hexagonal, 13 in one series on right side and two series of 10 in the inner and seven in the outer on left side. Though all enameled surfaces smooth median teeth show a number of vertical wrinkles extending more or less transversely over dental area, with pronounced ridge submedianly extending over at least first 12 median teeth. This ridge assymmetrical or a little nearer right than left side. At lateral portion of each median tooth are one or

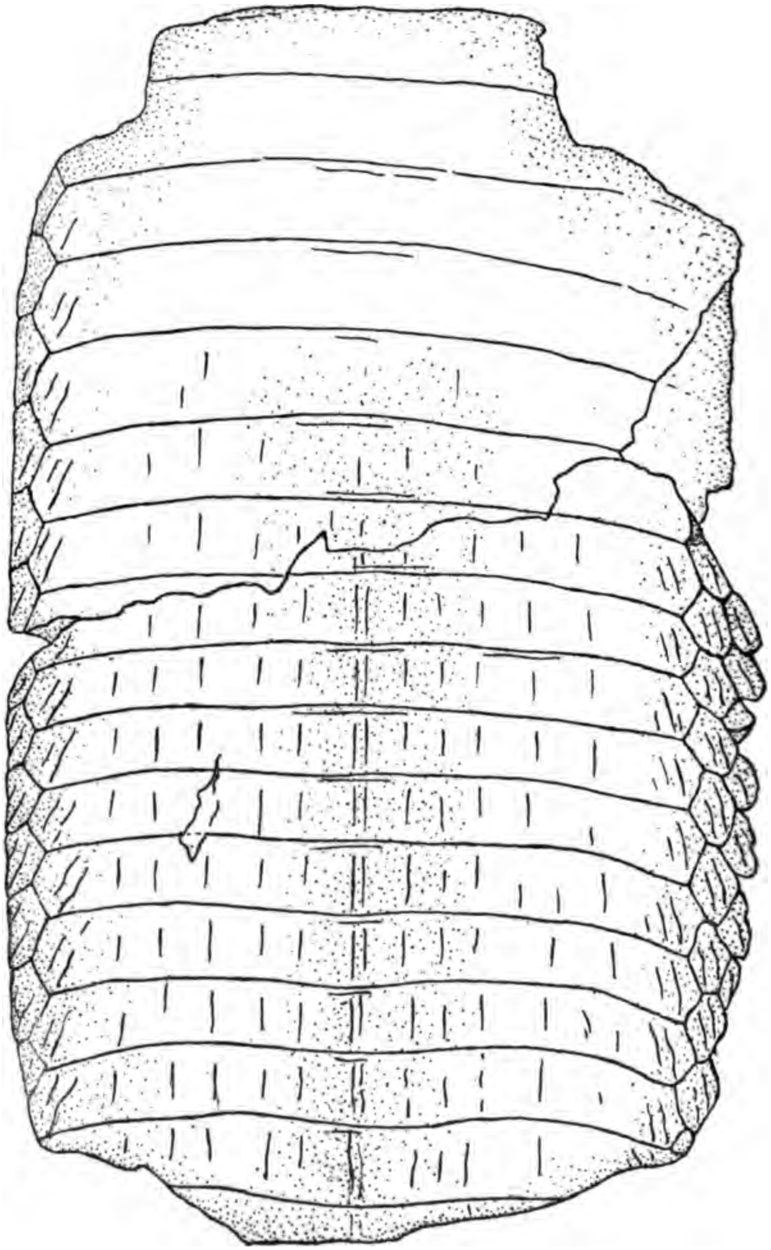

FIG. 49.—*Myliobatis kummeli* Fowler. (Type.)

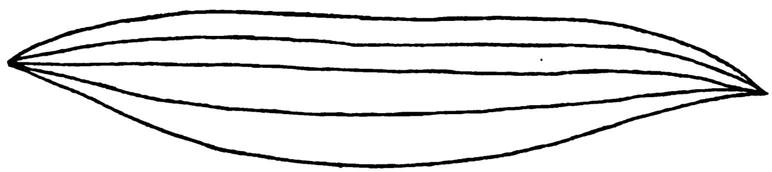

FIG. 50.—*Myliobatis kummeli* Fowler. (Type, in transverse sectional view).

two wrinkles of enameled surface, directed obliquely towards central keel. Similar wrinkles occur on each lateral tooth. Length (width) about 100 mm.

This species is only known to me from the above-described dental plate, which is nearly entire. It seems to differ from any other American species, and certainly from any I have examined in the lateral wrinkles on the enamel, which are not only distinct on the lateral teeth, but also on the lateral moieties of the median as well.

Formation and locality. Specimen No. 7395, type, collection of the New Jersey State Geological Survey. From the marl of Stow Creek Township in Cumberland County [the so-called Shiloh marl, which is referable to the Kirkwood formations of the Miocene, K.] (Isaac Smalley in March of 1880).

(I take pleasure in dedicating this species to Dr. Henry B. Kümmel, the State Geologist of New Jersey.)

MYLIOBATIS PACHYRHIZODUS sp. nov.

Dental plate depressed in form, thick, especially medianly, composed of seven median teeth, and at least two series of lateral teeth. Enamel surface slightly convex, with slight median depression, scarcely concave, also each side sloping very slightly to edges. Basal surface greatly convex, formed as median elevated axis from which each side slopes abruptly down. Transverse median sutures rather evenly and distinctly convex. Vertical diameter of median teeth about one-fifth of horizontal diameter. Lateral teeth rather large, only on right side, four in inner and apparently same number in outer series. Enamel surfaces smooth, without any very distinct wrinkles. Length (width) about 53 mm.

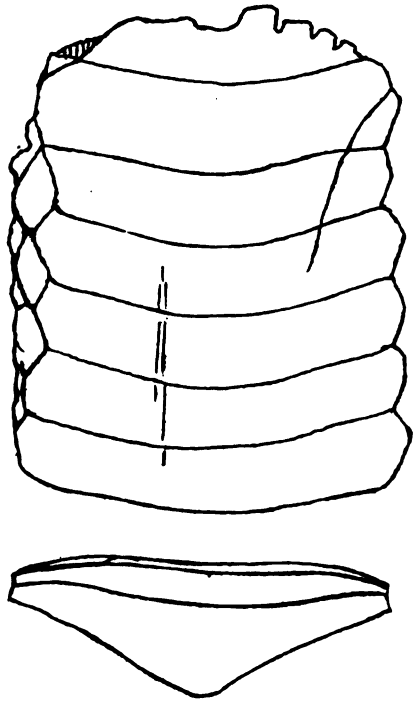

FIG. 51.—*Myliobatis pachyrhizodus* Fowler. (Type.)

Known from the above-described dental plate, unfortunately imperfect. This species is distinguished by its very thick root.

Formation and locality.—Specimen No. 6660, type, in the collection of the Geological Survey of New Jersey, and is from the upper marl [Manasquan, K.] at Poplar.

(*Pachyrhizodus*, i. e., thick-rooted tooth.)

Genus AETOBATUS Blainville.

Aetobatus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 112. Type *Raja narinari* Euphrasen, tenth species, virtually restricted by Gill, Proc. U. S. Nat. Mus., 1894, p. 112.

Ætobatis, Ætobatus, Aetobatis, Aetobates, auct.

Goniobatis Agassiz, Proc. Boston Soc. N. H., VI, 1839, p. 385. Type *Raja flagellum* Schneider, monotypic.

Stoasodon Cantor, Journ. Asiat. Soc. Bengal (Cat. Malay. Fish.), 1849, p. 434. Type *Raja narinari* Euphrasen, monotypic, and name based on *Ætobatis* Müller and Henle=Blainville.

Differs from *Myliobatis* in having the teeth uniserial, very broad, and no small lateral ones. Upper dental lamina straight and lower lamina projecting beyond upper, curved. Free hind edge of nasal valve deeply emarginated.

A single existing species in tropical seas, and 13 extinct species have been described, the latter only known from dental plates.

AETOBATUS PERSPICUUS (Leidy).

Aetobatis perspicuus Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 396. *Monmouth Co., N. J. Eocene?*

Ætobatis perspicuus Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 244, Pl. 31, fig. 13 (type).

Median tooth of dental plate well arched or angular, turning abruptly upward at end of tooth. Enamel surface rather broad, flat, and end only slightly rounded. Greatest width or vertical diameter of enameled surface usually uniform, and about one-seventh in entire horizontal diameter. Anterior edge of tooth angularly convex greater part of its extent, feebly deflected for-

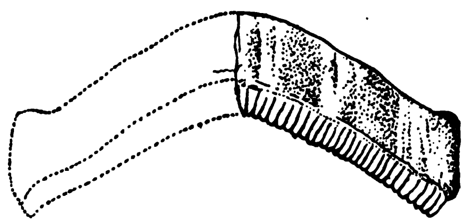

FIG. 52.—*Aetobatus perspicuus* (Leidy). (From Leidy.)

ward laterally, and at end presents projection adapted to crescentoid depression or socket of contiguous tooth. Posterior edge presents a narrow flange along greater portion of its length, and crescentoid socket at end of tooth adapted to receive projecting border of contiguous tooth. Root with laminæ projecting posteriorily about space equal to one-half vertical diameter of enameled surface, and all directed obliquely towards median axis of tooth. Length (width) about 60 mm. (From Leidy.)

Formation and locality. Only the type known described above, from the Eocene of Monmouth County (J. L. Burtt), originally presented to the Academy, but which I have not seen.

Genus PLINTHICUS Cope.

Plinthicus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 316. Type *Plinthicus stenodon* Cope, monotypic.

Known from thin and rather depressed teeth. Related to Aëtobatus, but differing in having the roots of the teeth projecting but slightly posterior to enameled surface.

One species described, extinct.

PLINTHICUS STENODON Cope.

Plinthicus stenodon Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 316. *Shiloh, Cumberland Co., N. J. Miocene.*

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 33, fig. 10 (type).

Dental plate greatly depressed, mostly with transverse or horizontal teeth nearly straight or but slightly and rather evenly con-

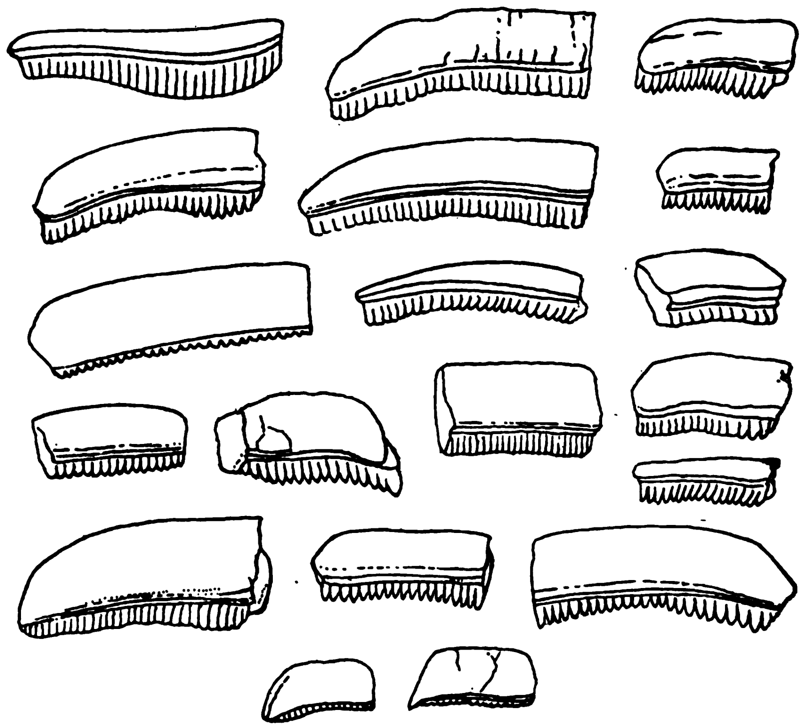

FIG. 53.—*Plinthicus stenodon* Cope. Charles Co., Md. (Thomas).

vex. Enamel surface broad, depressed or usually more or less flattened, and edges of front teeth at least varying more or less convex. Greatest width or vertical diameter of enameled surface usually uniform, and about one-fourth in entire horizontal diamater. Root low, greatly depressed, greatly inclined backward, so that beginning of lower level surface is about opposite medial lesser diameter of enameled surface. Posterior part of root always seen projecting a little more or less for slight distance behind enameled surface as latter is viewed from above. Entire surface of root marked with moderately numerous sutures, all parallel, and most distinct behind. Front edge of enamel surface curves slightly convexly over root, leaving a slight longitudinal groove below. Posterior edge just below enamel with a slight longitudinal ridge. Length (greatest breadth) 40 mm. Here described from examples from the Maryland Miocene.

Known only from the dental plates.

Formation and locality. I have not examined any examples from New Jersey where it has been ascribed to the Miocene. Cope originally had a single example and I do not think any others have been recorded from the State since [Shiloh marl, Kirkwood formation, Miocene, K.].

Genus RHINOPTERA Cuvier.

Rhinoptera (Kuhl) Cuvier, Règne Animal, Ed. 2, II, 1828, p. 401. Type *Myliobatis marginata* G. St. Hilaire, first species, restricted by Bonaparte, Nuov. Ann. Sci. Nat. Bologna, II, 1838, p. 201.

Zygobatis Agassiz, Poiss. Foss., III, 1843, p. 79. Type *Myliobatis jussieui* Cuvier, virtually monotypic.

Zygobates, auct.

Trikeras Harless, Abh. N. Phys. Class., V, 1850, p. 841. No species given.

Mylorhina Gill, Ann. Lyc. Nat. Hist. N. Y., 1865, p. 136. Type *Rhinoptera lalandii* Müller and Henle, designated, monotypic.

Micromesus Gill, l. c. Type *Rhinoptera adspersa* Müller and Henle, designated, monotypic.

Trycera (Koch) Doderlein, Man. I. Med., III, 1885, p. 242. Type *Trycera typica Koch* (= *Myliobatis marginata* G. St. Hilaire), nom. in syn.

This genus resembles *Myliobatis* in its dentition, having the teeth in several series, the median being very broad. It differs, however, in the emarginated muzzle and having the cephalic fins below the level of the disk.

The existing species, about 10, distributed in tropical seas. About five extinct species have been described.

RHINOPTERA DUBIA Leidy.

Dental plate depressed, evidently upper or enameled surface well convex and lower or basal surface equally concave, though both surfaces evenly so. Enamel surface smooth, of usually even thickness, and edges usually abrupt. Extremities of tooth form rather obtuse angle, and apex would form medianly in vertical diameter. Vertical diameter of enamel surface nearly one-seventh of horizontal. Root not visible as enameled surface is viewed from above, low, greatly depressed, sometimes moderately deep. and uniformly concave. Vertical grooves rather variable, numerous or moderate. Greatest breadth 46 mm.

This species does not ever appear to have been noted from New Jersey before. Many of my examples agree entirely with Leidy's, but other specimens must be admitted somewhat provisionally, as they are possibly teeth belonging to *Myliobatis*. Known only from detached teeth or dental plates.

Formation and locality. The following examples in the collection of the Academy have been examined: Monmouth County 10 (W. Cleburne) and 2 (P. D. Knieskern); Vincentown, in the marl of Burlington County 1 (C. B. Barrett), and 1 said to be from the Miocene labeled "Bridgeton Pike" (C. C. Abbott).

I have also examined some fragmentary dental remains in the collection of the Geological Survey taken from well-borings at 214 feet on July 23d, 1909, on the beach front at Bradford Cottage, Fortesque, in Cumberland County. From 200 to 214 feet the shell-beds were in a tough, leathery mud, and in this horizon were found the fragments of the present species. For information and these specimens the Survey is indebted to Mr. S. P. Foster, of Elmer, and Mr. C. Holaday, of Hornersville. A comparison with a large series of examples from the Maryland Miocene, with which they agree in most respects, would point to their being from the same formation.

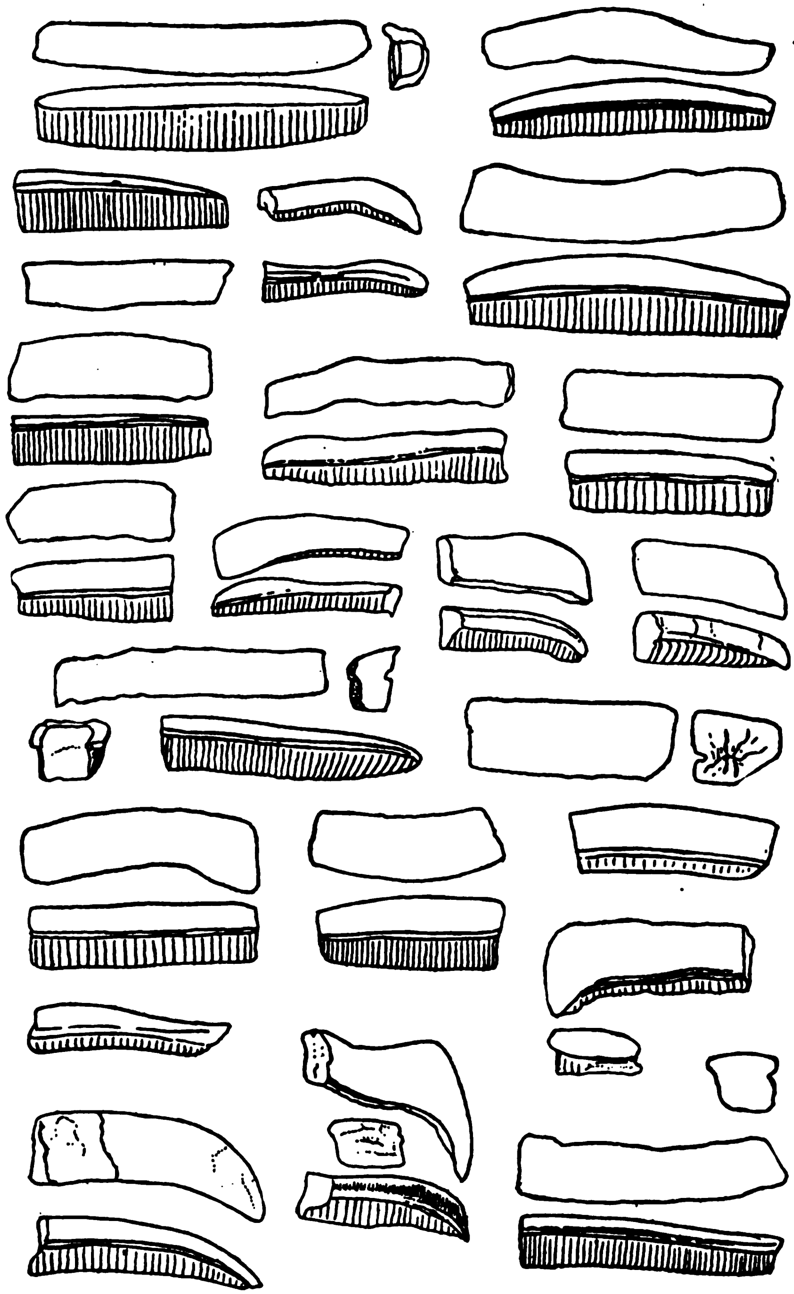

FIG. 54.—*Rhinoptera dubia* Leidy. Charles Co., Md. (Thomas).

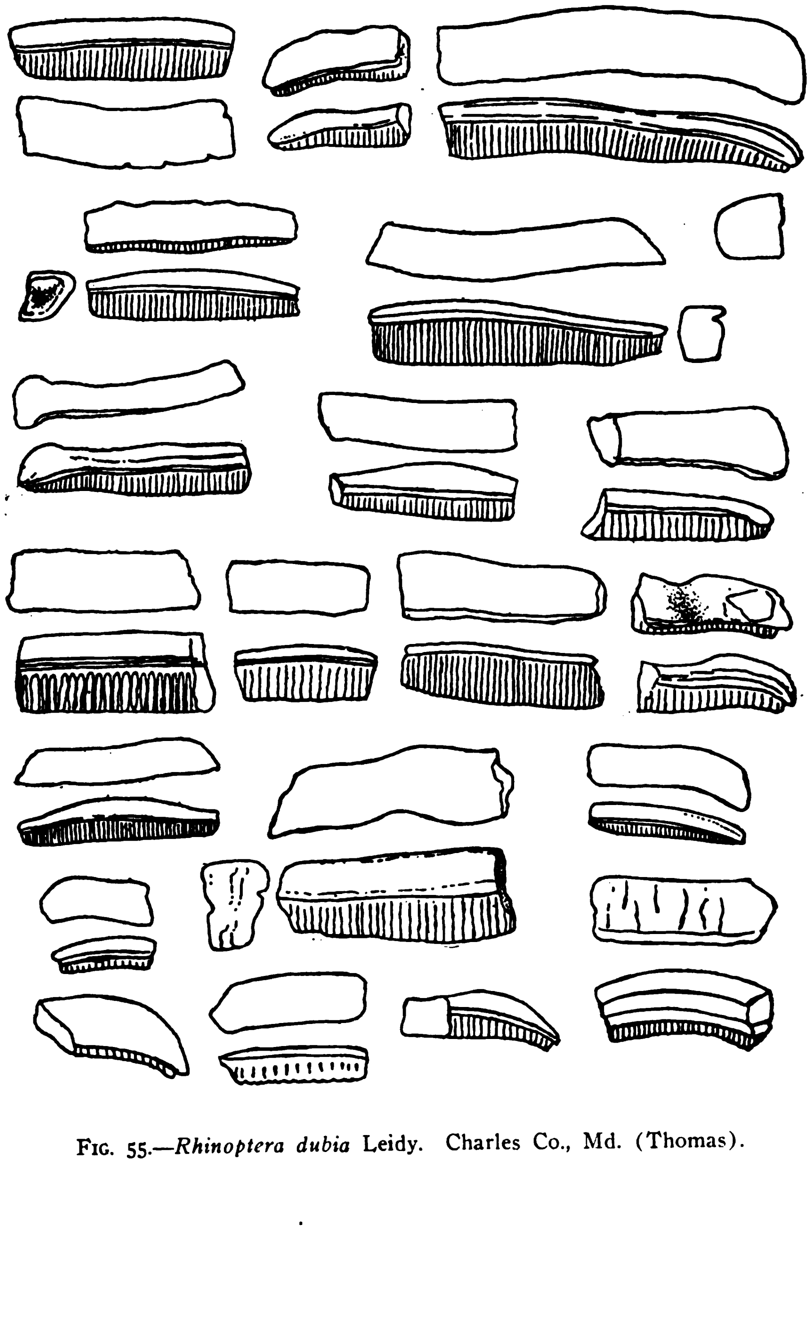

FIG. 55.—*Rhinoptera dubia* Leidy. Charles Co., Md. (Thomas).

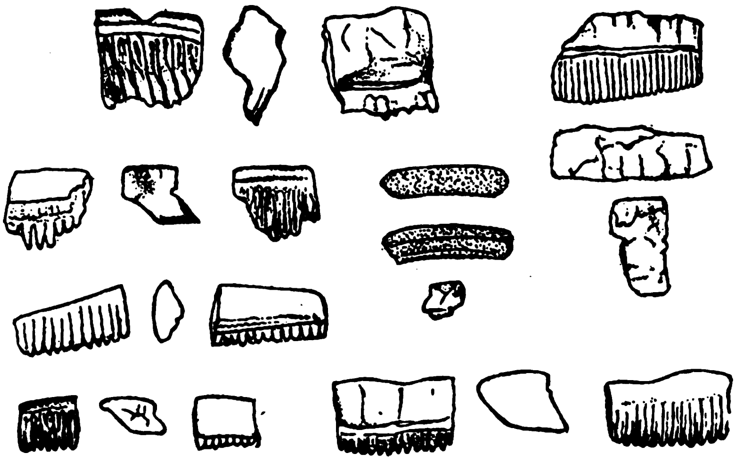

FIG. 56.—*Rhinoptera dubia* Leidy. *Fortesque.

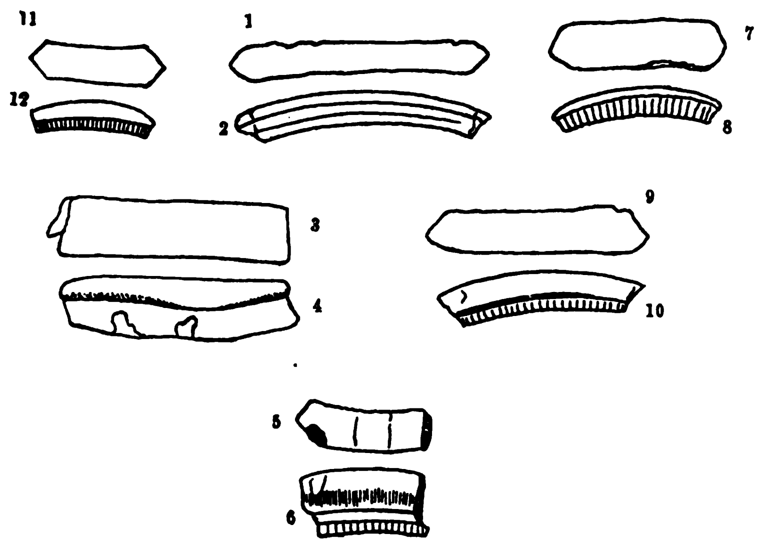

FIG. 57.—*Rhinoptera dubia* Leidy. 1–2, Monmouth Co. (Knieskern); 3–8, Monmouth Co. (Cleburne); 9–10, Vincentown (Barrett); 11–12, Bridgeton Pike (Abbott).

FRAGMENTARY SELACHIANS.

A large number of detached vertebræ (Figs. 58, 59) are in the collection of the Academy, representatives of which I have fig-

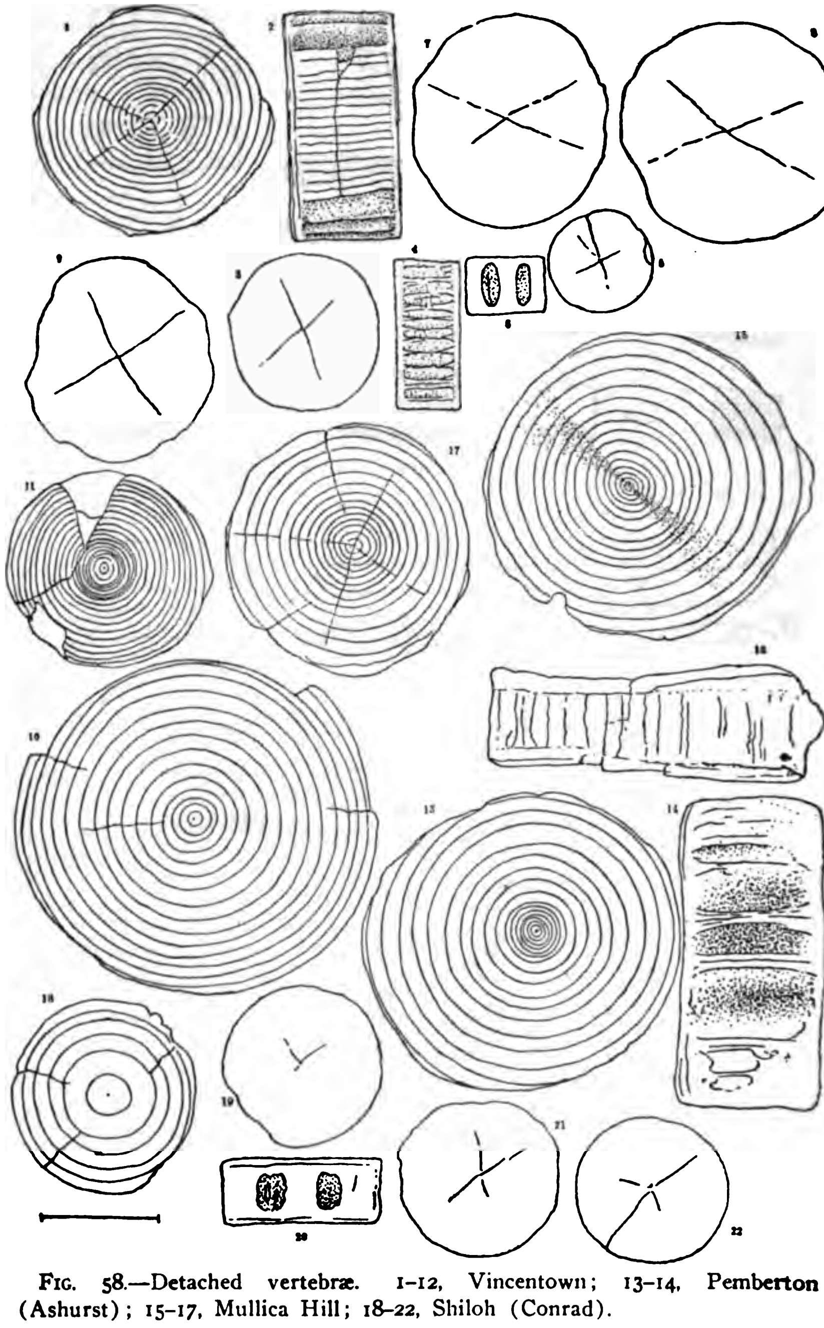

FIG. 58.—Detached vertebræ. 1–12, Vincentown; 13–14, Pemberton (Ashurst); 15–17, Mullica Hill; 18–22, Shiloh (Conrad).

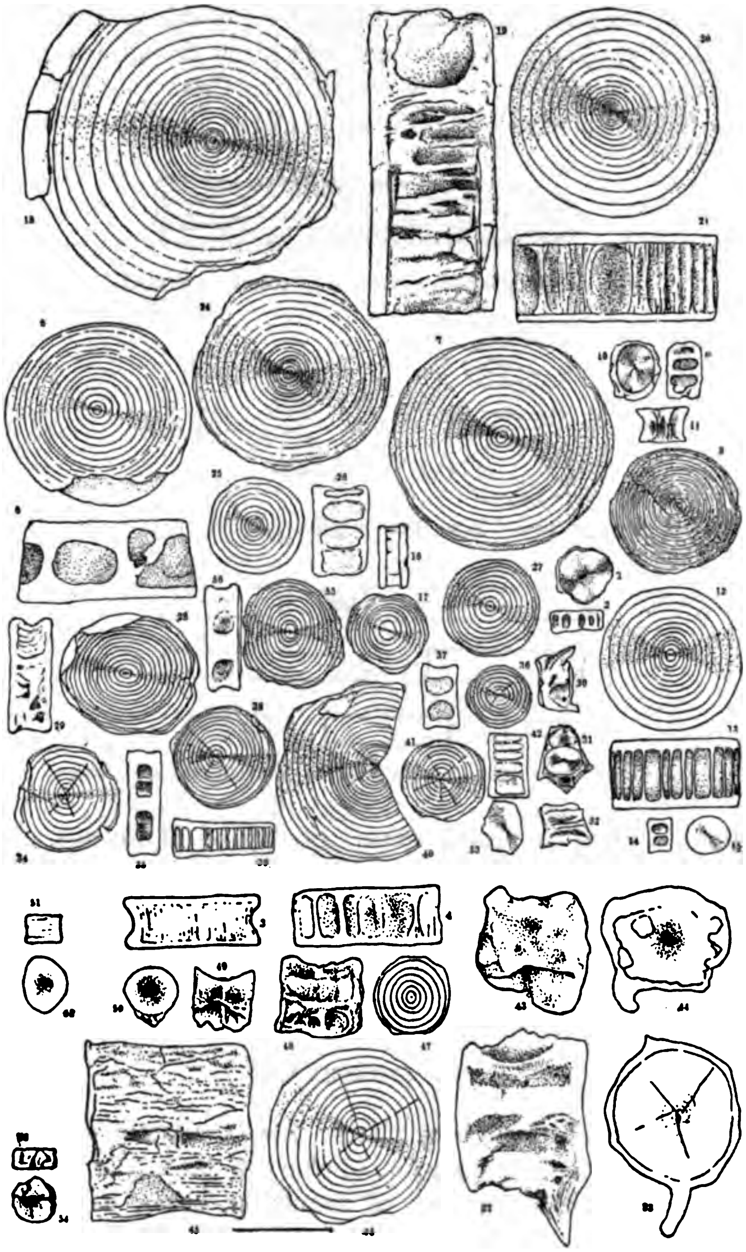

FIG. 59.—Detached vertebræ. 1–2, New Jersey (Abbott); 3–4, Long Branch (Chapman); 5–6, Monmouth Co. (Slack); 7, Monmouth Co (Vandyke); 8, Monmouth Co. (Abbott); 9–11, Monmouth Co. (Cope); 12–15, Monmouth Co. (Cleburne); 16–17, Farmingdale (Pilsbry); 18–21, New Egypt (Chaloner); 22–23, Pemberton (Budd); 24–26, Pemberton (Ashurst); 27–44, Vincentown (Bryan); 45–46, Blackwoodtown (Lamb); 47–48, Allowaystown (Yarrow); 49–50, Lenola (Conard); *51–52, Wenonah Sand; *53–54, Hurffville (Hurff); 55–56, Charles Co., Md. (Thomas).

ured in this connection, though I have been unable to locate their true identity. Many are, no doubt, selachians, though many may also belong to teleosts. They are all from Cretaceous beds, but are without stratigraphical position, like most all of the older col-

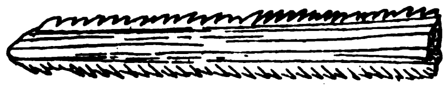

FIG. 60.—*Myliobatis* spine? Vincentown (Bryan).

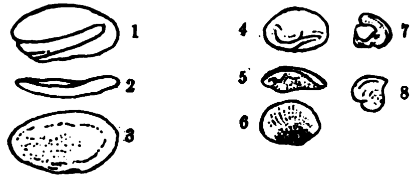

FIG. 61.—Teleost otoliths. 1-3, Haddonfield; 4-8, Mt. Laurel (Woolman).

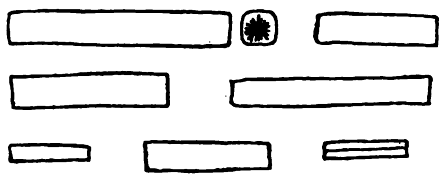

FIG. 62.—Rays from a batoid fish? Vincentown (Bryan).

lections. There is also a spine, possibly of *Myliobatis* (Fig. 60), and several teleost otoliths (Fig. 61). Several small, thin, rod-like fossils may also belong to rays (Fig. 62).

Sub-Class HOLOCEPHALI.

THE CHIMÆRAS.

Teeth united to form bony plates. Jaws coalescent with skull. Gill-openings single in each side of pharynx, leading to four gill-slits. Skull without system of membrane bones, as opercles, suborbitals, etc. Skeleton cartilaginous. Mandibular suspensorium wanting. Intestine with a spiral valve. Derivative radii sessile in sides of basal bones of limbs. Pectoral fins normally

developed, placed low. Ventral fins abdominal. Males with claspers attached to ventrals. Skin scaleless, its muciferous system well developed.

This group generally includes six families.

Order CHIMAEROIDEI.

Characters included in those of the sub-class.

Family CHIMÆRIDÆ.

THE CHIMÆRAS.

Body elongate, rather robust anteriorly, tapering posteriorly. Head compressed. Mouth inferior, small. Upper lip deeply notched. Jaws with teeth confluent into four bony plates above and two below. Nostrils confluent with mouth, separated by narrow isthmus. Free gills 3, half gills 2, one on each side. Rakers small. Isthmus moderate. Males usually with cartilaginous hook on snout above, prickly at tip, turned forward. No spiracles. Skin naked, rarely somewhat prickly. Lateral line present, usually branched anteriorly. Dorsal usually divided, anteriorly with strong posteriorly grooved spine. Caudal low, fold-like. Pectorals free, low. Ventral abdominal, many rayed. Males with claspers.

The existing forms are remarkable for their striking appearance. They are all natives of deep water and cold seas. Reproduction is oviparous, the egg-cases long, elliptical and with silky filaments. About 17 genera have been described, all extinct, and only *Chimæra* persisting to the present time. Possibly *Chimæra affinis* (Capello) may occur in deep water off our coast, though it has not ever been so recorded.

Passalodon was founded on vomerine teeth and *Psittaoodon* on mandibular teeth of two European fossils. Woodward says[1] "the species mentioned below have also been determined upon

[1] Cat. Foss. F. Brit. Mus., II, 1891, p. 84.

the evidence of detached teeth, and, by a misunderstanding of the generic characters, the majority of the American forms have hitherto been ascribed to *Ischyodus*. Most of the type specimens of the latter are in the collection of Prof. E. D. Cope, Philadelphia, where the present writer has had the privilege of examining them, and many of the specific distinctions cited in the diagnoses would be regarded as varietal in Britain." However, the present writer seems justified in following the views of Hussakof, who has studied these specimens now in the American Museum of Natural History in New York City.

Genus EDAPHODON Buckland.

Edaphodon Agassiz[1], Poiss. Foss., III, 1843, p. 351. Type *Edaphodon bucklandi* Agassiz, restricted by Woodward, Cat. Foss. Fishes, II, 1891, p. 80.
Edaphodus, auct.
Passalodon Buckland, Proc. Geol. Soc. London, II, 1838, p. 687. No description or species.
Psittacodon Agassiz, Poiss. Foss., III, 1843, pp. 340, 348. Type *Chimæra mantellii* Agassiz, virtually designated, first species.
Dipristis Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 230. Type *Dipristis miersii* Marsh, monotypic. (Not of Gervais.)
Eumylodus Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, p. 309. Type *Eumylodus laqueatus* Leidy, monotypic.
Diphrissa Cope, Proc. Acad. Nat. Sci. Phila., 1875 (Feb. 9th)[2], (2) p. 19. Type *Ischyodus solidulus* Cope, designated, monotypic.

Mandibular tooth massive, with no definite thickening on outer aspect, symphyseal facette very broad. Anterior tritor 1, sometimes smaller one below. Median tritor 1, occasionally divided longitudinally. External tritors 2. Palantine teeth robust, no well-defined thickening on outer aspect, and three tritors as two inner and one outer. Vomerine teeth mostly triangular in side view, tritors on oral edge. Postoral region laterally expanded, without any thickening.

The species, about 26, are all extinct.

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[1] Buckland, Proc. Geol. Soc. Lond., II, 1838, p. 687. Descr. imperfect, no species given.

[2] Issued April 20th, 1875.

Edaphodon stenobryus (Cope).

Ischyodus stenobryus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 285. *Hornerstown, N. J., Greensand No. 5.*

Edaphodon stenobryus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39, Pl. 2, figs. 6–7 (types).

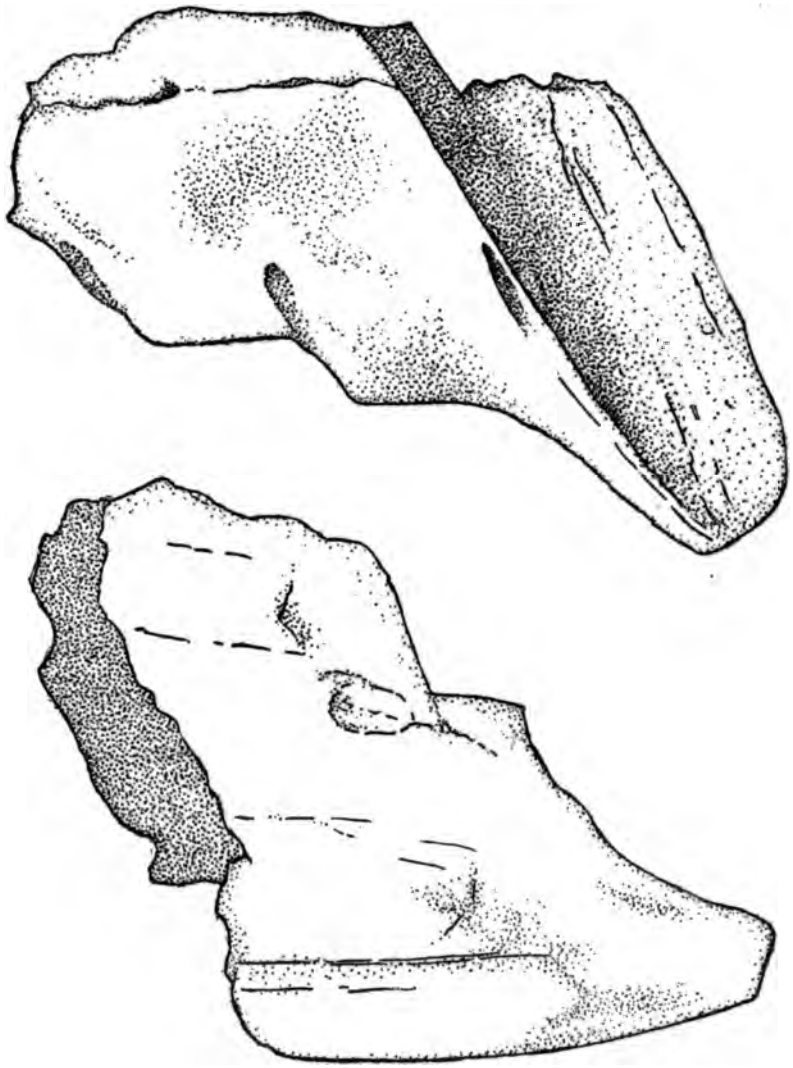

Fig 63.—*Edaphodon stenobryus* (Cope). (From Hussakof.)

Mandibulars compressed, outer edge rising rapidly from little behind apex, first to a shoulder which supports first exterior dentinal area, and then steeply to an oblique border which bears hind dentinal area. Dentinal areas very small, inner represented by two columns widely separated from each other. Inner masticatory margin remains parallel with lower edge of jaw, marking one-third total depth. Grinding face vertical behind. External areas very narrow, and behind anterior smaller one appears in position of inner one of *E. tripartitus,* thus representing outer part of large removed from former, narrow, and extends little anterior to anterior border of anterior outer. Apex of jaw obtuse, and terminal area on its superior aspect oval, and continues as edge of a lamina along outer margin of beak. No symphyseal plane, whole jaw much compressed and narrowed. Length 70 mm. (From Cope.)

Said to have much the form of *Leptomylus forfex,* and approaching *E. laterigerus.*

Formation and locality. Only known from the type, a pair of mandibulars now in the collection of the American Museum, N. Y. They are from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County. I have not seen this species.

EDAPHODON TRIPARTITUS (Cope).

Ischyodus tripartitus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 286. *Hurffville, N. J. Upper bed of Greensand.*
Edaphodon tripartitus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 40, fig. 16, Pl. 3, figs. 5-6 (types).
Ischyodus mirificus (nec Leidy) Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 314 (note).
Ischyodus longirostris Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 287. *Birmingham, N. J. Greensand No. 5.*

Mandibulars little more than twice as long as deep, rami converging in slight curve and ending in narrow produced symphyseal beak. Outer face of mandible with two longitudinal convexities, inner nearly vertical, and with short symphyseal plane. Dentinal areas moderate, anterior border not much produced, inner represented by three adjacent areas or three columns united at their adjacent borders, and outer more than twice as large as either of two interior ones. Latter separated from inner angle of

jaw by an oblique plane of same width. External areas narrow, posterior quite small, anterior elongate and extends far in advance of inner areas along summit of horizontal ridge, latter produced as strong step on outer margin. Outer narrow border rises abruptly opposite middle of anterior area, causing masticatory face to be very oblique at that point. Superior groove wide, outer face not produced. Length 175 mm. (From Cope.)

This is the largest American species of the genus and said to be not uncommon. Hussakof has united *Ischyodus longirostris* Cope with this species after an examination of the types. According to Cope the former differed in having the inner dentinal area of the mandibular undivided, contracted and separated by a plane from inner margin. Outer posterior area lost in his specimen, but outer anterior opens in front of interior on horizontal step which forms strong angle of outer border. This border, therefore, abruptly excavated from that point forward, while inner border descends gradually from inner angle. Terminal area quite large and oblique. Symphyseal face large, inferior border of jaw obtuse and jaw end narrowly compressed. Palatal characterized by its small size and posterior position of anterior dentinal area, so that bone appears more produced. Posterior areas large.

Formation and locality. The type, consisting of both mandibulars and left palatal, are from Hurffville in Gloucester County. The type of *I. longirostris* consists of one mandibular and one palatal, both from Birmingham in Burlington County (J. C. Gaskill). All are recorded as from the greensand No. 5. [According to the present classification all would be referred to the Hornerstown marl, although at both these localities the Hornerstown and Navesink marl beds are united in a single layer, so that they may be from the Navesink or lower member, K.]. They are now in the American Museum of New York. I have not examined these specimens.

EDAPHODON LATERIGERUS (Cope).

Ischyodus laterigerus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 243.
Hornerstown, New Jersey. Cretaceous Greensand No. 5.
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 288 (type).
Edaphodon laterigerus Hussakof, Bull. Amer. Mus. N. H., XXV., 1908, p. 38, Pl. 1, figs. 7-8 (type).

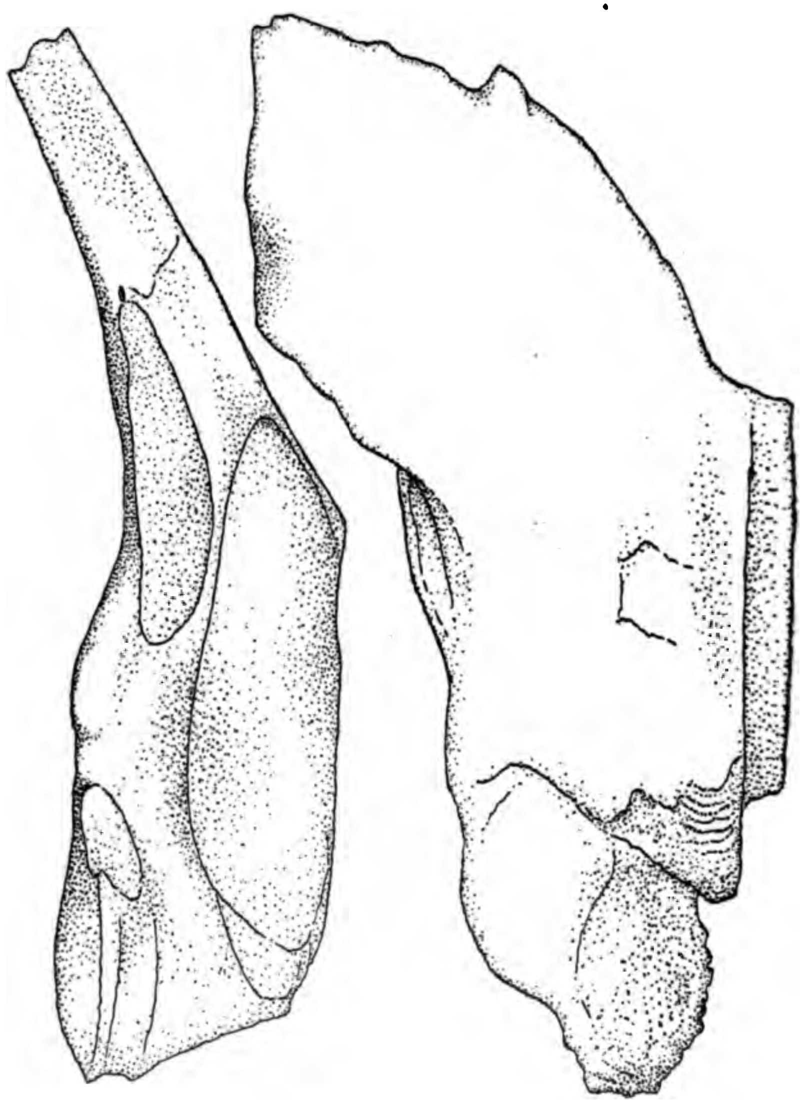

FIG. 65.—*Edaphodon laterigerus* (Cope). (Type, from Hussakof.)

Mandibular little more than twice as long as deep, end prolonged and more flattened than any other species from our region, and thoroughly and regularly curved outwards and backwards. Inner dentinal area undivided, extending to inner margin of superior face of mandible, large in all dimensions. Below

a slender intero-lateral column. Anterior area produced anterior to inner area. External areas on laminar crests of border, posterior area very small or less than one-third anterior, and anterior crest produced, or long and narrow, its middle marking anterior end of great inner area. When two mandibular rami are in place it follows from the above that median line of beak forms deep concavity walled in by high anterior outer crest. Posterior outer crest well developed, also prolonged acutely beyond posterior dentinal area. External terminal column largely developed vertically. Length about 165 mm. (From Cope.)

Known only from the above example, the type, said by Cope to approach *E. smockii,* but of double its size, more compressed and curved, with a much smaller posterior outer dentinal area and a very long anterior outer crest.

Formation and locality. The type is a large left mandibular, almost perfect, from the marl [Hornerstown K.] at Hornerstown in Monmouth County (J. C. Meirs), now in the American Museum at New York. I have not examined this specimen.

EDAPHODON SMOCKII (Cope).

Ischyodus smockii Cope, Proc. Boston Soc. N. H., XII, 1869, p. 316. *New Jersey. Cretaceous Greensand.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 288. Hornerstown. Greensand No. 5.

Edaphodon smocki Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39, Pl. 2, figs. 4-5 (type).

Mandibular moderately long and stout. Outer face uniformly concave transversely, inner also with longitudinal concavity much stronger. Surface striæ longitudinal, sometimes broken. Dentinal areas large, surfaces rather plane, elevated supero-anteriorly, and plane of posterior face descends abruptly from supero-anterior margin of each. Outer margin, therefore, an incline of two steps, inner of one. Outer areas narrowed in front, and inner areas more obtuse and large, separated by very narrow strip from outer posterior, undivided and extending to inner margin of superior face of mandible. Length about 58 mm. (From Cope.)

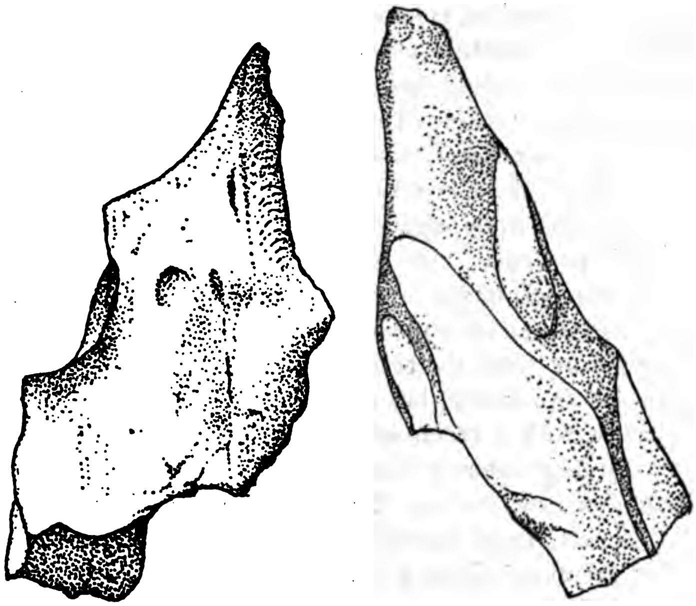

FIG. 66.—*Edaphodon smockii* (Cope). (Type, from Hussakof.)

This seems to be a well-marked species, about half the size of the smaller *E. divaricatus*. It is much less stout than in the latter and also less elongate than *E. tripartitus*.

Formation and locality. Known from the types in the American Museum at New York, consisting of three mandibular teeth and two fragments, and one of these represented only by an anterior extremity is thought by Hussakof to be probably different. They are all ascribed to the Greensand No. 5 [Hornerstown marl, K.] from Hornerstown in Monmouth County (J. C. Miers). I have not examined any specimens.

EDAPHODON EOCÆNUS (Cope).

Ischyodus eocænus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 288. *Eocene greensand of Farmingdale, Monmouth Co., N. J.*
Edaphodon eocænus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 37, fig. 14 (type).

Mandibular with outer border of beak rising abruptly to considerable elevation, supporting anterior outer dentinal area. Lat-

ter oval, well within border, cut off at its posterior portion, but in advance of position of inner area. Dentinal areas moderate, inner undivided, extending to inner margin on upper face of mandible, and outer area produced anterior to inner area. Inner and posterior outer dentinal areas lost. Length, to anterior outer area, 50 mm. Terminal column laminar, extending well back on outer edge of beak. Outer face of jaw uniformly convex to anterior outer area, apex transverse, not compressed. Symphyseal face not well marked. (From Cope.)

This species is stated by Cope to be quite near *E. mirificus*, differing in uniform convexity of outer face, which in the latter is

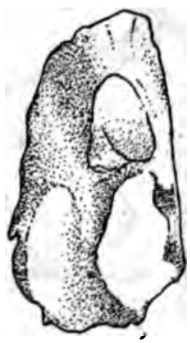

FIG. 67.—*Edaphodon eocænus* (Cope). (Type, from Hussakof.)

partially concave. Cope says the palatal areas are large, elongate, but not on elevated bases as in *E. smockii*. Outer face of palatal smooth, lower border very oblique to interior, which is longitudinally grooved. The specimen he had included five dentinal columns, inner borders more or less exposed, and median or interior column longest. This piece was similar in generic characters to that of *E. mirificus*.

Formation and locality. The type consists of a mandibular in the American Museum at New York. Two paratypes are a palatal and a fragment, all from the Eocene greensand of Farmingdale in Monmouth County. I have not examined any examples.

EDAPHODON INCRASSATUS (Cope).

Ischyodus incrassatus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 289. *Hornerstown, New Jersey. Greensand of Cretaceous No. 5.*
Edaphodon incrassatus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38, Pl. 1, figs. 5-6 (type).

Mandibular with beak little curved outward, long, thick, symphyseal face a narrow border along inner edge. Convexity of lower half of outer face of jaw very strong, so that lower border thicker than in any other of our species. Inner dentinal area undivided, of median extent, extending to inner margin of superior face of mandible, apex marking only middle of anterior oval outer area instead of anterior extremity, latter horizontal on a considerable tuberosity removed well within outer border of jaw so that latter not angulated there as in some similar species. Length 125 mm. (From Cope.)

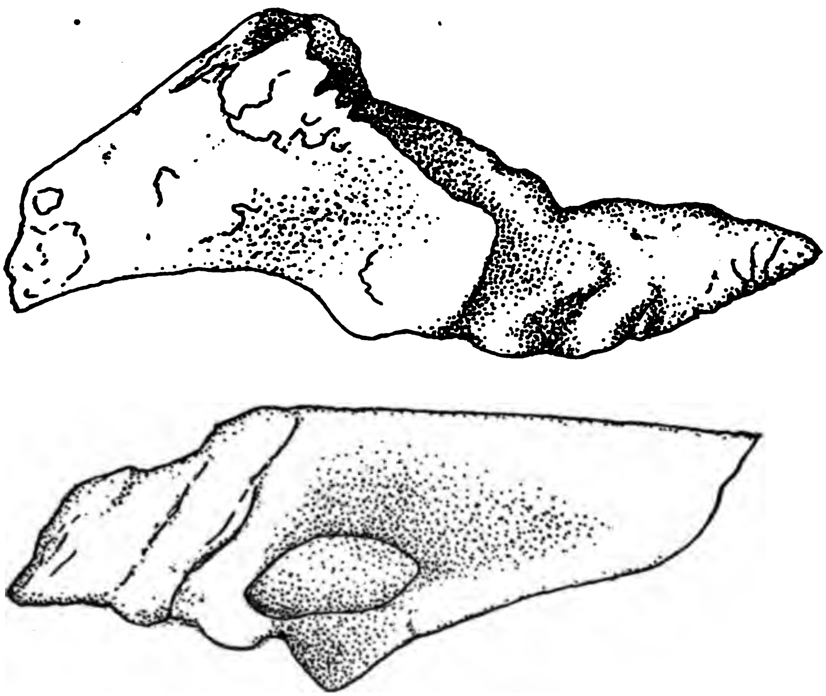

FIG. 68.—*Edaphodon incrassatus* (Cope). (Type, from Hussakof.)

Formation and locality. Only known from the type, an imperfect right manibular in the American Museum at New York, from the "Greensand of the Cretaceous No. 5" [Hornerstown marl, K.] at Hornerstown in Monmouth County (J. G. Miers). I have not examined this example.

EDAPHODON FECUNDUS (Cope).

Ischyodus fecundus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 290. *Medford, N. J. Greensand of Cretaceous, No. 5, from Birmingham and Hornerstown.*

Edaphodon fecundus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38 (type).

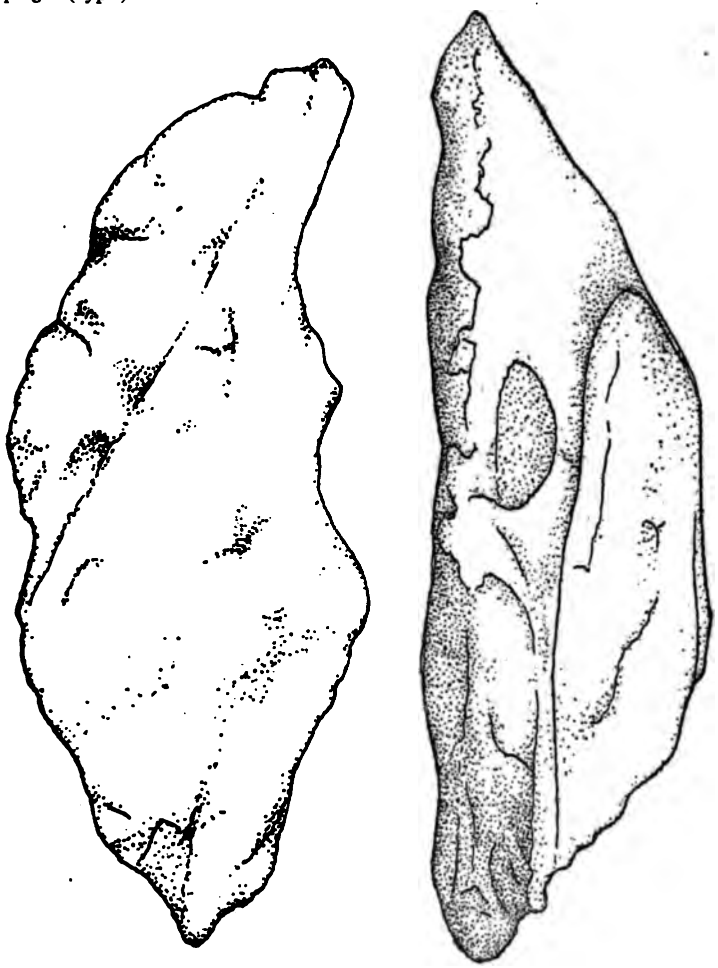

FIG. 69.—*Edaphodon fecundus* (Cope). (Type, from Hussakof.)

Mandibular moderately long, long axis strongly curved, and outer side concave in vertical as well as transverse section. Inner face also concave, with narrow symphyseal plane along inner border. Inner border of beak with same abrupt descent as outer. Dentinal areas moderate, inner undivided, both narrowed anteriorly and terminating on same transverse line. Anterior outer

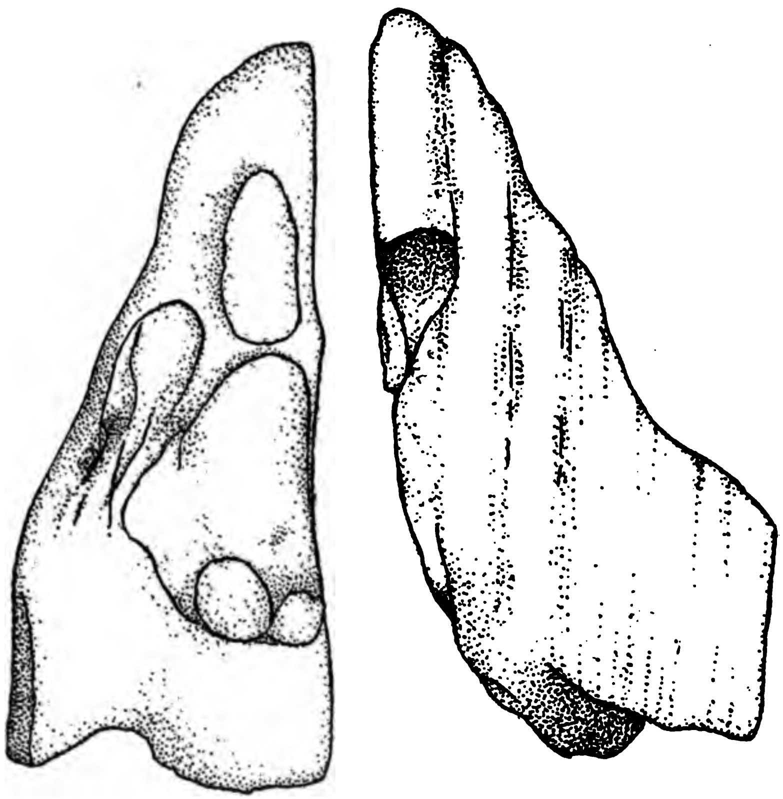

FIG. 70.—*Edaphodon fecundus* (Cope). (Type, from Hussakof.)

rather small and wide, horizontal, so that apex rises abruptly above outer border of beak. Posterior outer area rather small, while inner large and extending to inner edge of upper face of mandible. Apical column an oblique lamina. Length 135 mm. (From Cope.)

According to Cope this species is second in size in the genus to *E. tripartitus* or about twice the size of *E. smockii*. Palatals nar-

rowed and truncate in front, and dentinal areas large, especially posterior. Superior groove deep, and outer face extensive and longitudinally ridged.

Formation and locality. Known from eight lower jaws, some with palatals, of which seven mandibulars and one palatal are in the American Museum of New York. They are from the marl [Hornerstown marl, K.] at Birmingham and Hornerstown. Cope also had an example from Medford. I have not seen any material.

EDAPHODON MIRIFICUS Leidy.

Edaphodon mirificus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Burlington Co., N. J. Cretaceous Greensand.*
Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, pp. 306, 350, Pl. 37, figs. 6–12 (types).
Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 38, Pl. 2, fig. 3 (Cope's material).
Ischyodus mirificus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 291. (Barnesborough and Hornerstown, N. J. Greensand No. 5.)
Ischyodus monolophus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 314. *Barnesboro* (Barnesborough), *Gloucester Co., N. J. Greensand.*
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 289 (type, Greensand No. 5).
Ischyodus gaskillii Cope, l. c., pp. 285, 290. *Birmingham, Greensand of New Jersey, No. 5.*

Mandibulars a little more than twice as long as deep, rami converging in a curve and ending in a long, symphyseal, bird-like beak. Outer surface of each mandibular concave medianly and convex above and below. Outer profile concave anteriorly, then sloping up convexly, and below and behind convex. Inner symphyseal edge beveled, flat and rather narrow, and below this and posteriorly slightly convex with several longitudinal striæ. Oral surface of beak concave and posteriorly forms plane sloping inwards, this largest dental area. Anteriorly and externally another small rounded dental area, situated on a slight convexity, and followed back by a concavity at first rather spacious and then narrow where it separates a third dental area. Latter situated just inside external crest of mandible and about opposite middle in length of largest dental area, and elongate, though same width as anterior dental area about twice as long. A fourth short, nar-

row dental area on external oral extremity of beak, and another still shorter along inner edge. A fifth area, small, varying in elliptical pattern, at posterior symphyseal bevel opposite front of largest oral dental area, and followed by a prominent ridge which is convex with about two rather prominent longitudinal ridges, and curving back forms edge of mandible ramus posteriorly inside.

Upper maxillaries a little more than twice as long as wide, and their depth a little less. Form generally depressed. Upper surface of each with a deep wide gutter extending forward about two-thirds its length and ending in a deep pit, anterior to which area is

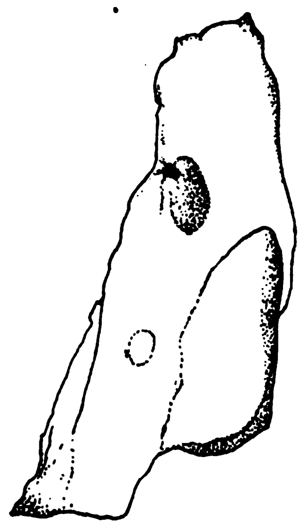

FIG. 71.—*Edaphodon mirificus* Leidy. (Type of *Ischyodus gaskillii* Cope, from Hussakof.)

flat and horizontal. Sides of upper maxillaries flat and sloping obliquely out. Lower surface with prominence in front sloping forward, its crest giving rise to an elongated round dental area sloping slightly down behind, where a crest forms, which gives rise in turn to largest dental area. Latter extends well back and close to inner edge, rounded, and also sloping down concavely behind, while laterally it also extends well towards outer edge. Just external to largest dental area another elongated dental area arising on a slight convexity opposite hind region of anterior dental areas, and extending back opposite deep posterior con-

cavity of largest dental area. Between anterior and lateral dental areas on oral surface a concave depression extending back to largest dental area. Posteriorly on oral surface externally edge arises in an elevated ridge, apex forming about opposite concavity in largest dental area, surface inside evenly concave. Inner surface of upper maxillary entirely flat.

As Leidy pointed out, the dental areas appear as white chalky friable spaces, which have more or less decomposed, leaving the little more durable tubules of the vaso-dentine projecting from their surfaces. He supposes originally tubecular structures were found over the dental areas covering the dental columns, but have now disappeared, leaving only their depressed and crumbling surfaces as now seen. These dental columns, corresponding with the dental areas, may all be located at the posterior ends of all the maxillaries. Length of longest lower maxillary 14 cm.

I have described several of Leidy's types above, now in the Academy, and note that the others agree in most respects, as he has already remarked. At present they are a pair of maxillaries and two pairs of mandibulars. Another small example, a right mandibular, agrees. It is from the New Jersey greensand, and shows a few transverse crescentic striæ on its damaged inferior surface.

Formation and locality. Known from the Cretaceous greensand at Barnsboro and Hornerstown [the Hornerstown marl probably, K.]. According to Hussakof *Ischyodus gaskillii* Cope and *I. monolophus* Cope, the types of which he has examined, and which are now in the American Museum at New York, are a small left mandibular, apparently of a young individual, and two mandibular teeth, respectively, of the present species.

I have also seen several examples in the collection of the Geological Survey. They are a right and left mandibular from the Cretaceous of "New Jersey," and one right and two left mandibulars without data.

Edaphodon miersii (Marsh).

Dipristis miersii Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 230. *Hornerstown, N. J. Upper Cretaceous Marl.*

Ischyodus miersii Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 292. (Hornerstown, Monmouth Co., N. J.)

Mandibular with long and straight beak, and outer face concave to base of anterior outer dentinal area. Long axis of jaw straight, also inferior border. Inner dentinal area undivided, transversely thickened, narrow and extending to inner edge of superior face of mandible. Anterior outer dental area not produced anterior to border of inner area, not on a projection, and not extending as far as inner. Apical area end of a curved laminar column. Length 100 mm. (From Cope.)

This species was originally described by Marsh from an ichthyodurlite he assigned to a chimæroid fish. It was a nearly perfect dorsal spine about 356 mm. long, somewhat curved, remarkably slender, tapering regularly to its apex, compressed transversely, outline generally suboval, posterior surface slightly concave in lower portion, upper half of this surface armed with two rows of very sharp decurved teeth while corresponding part of anterior face had sharp cutting-edge finely serrated toward distal end, and sides of spine smooth or faintly striated. He also noted that fragments of this species of much larger size were not uncommon in the same geological horizon in other parts of the State.

Formation and locality. Cope had a broken mandible and a dorsal spine, which latter he thought identical with the one noticed by Marsh. All the material examined by these two writers was from the upper Cretaceous marl bed near Hornerstown [the Hornerstown marl] in Monmouth County (J. G. Meirs). The identity of the mandible, described above from Cope, must be considered provisional, resting entirely on the fact that it was topotypic and has not been demonstrated positively to belong to the same fish to which the ichythodorulite belonged.

EDAPHODON DIVARICATUS (Cope).

Ischyodus divaricatus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 315. *Cretaceous marl of Burlington Co., N. J.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 292. (New Jersey greensand, No. 5, from near Hornerstown.)

Right mandibular a trifle more than twice as long as deep, and rami would apparently converge in a slight curve, nearly an

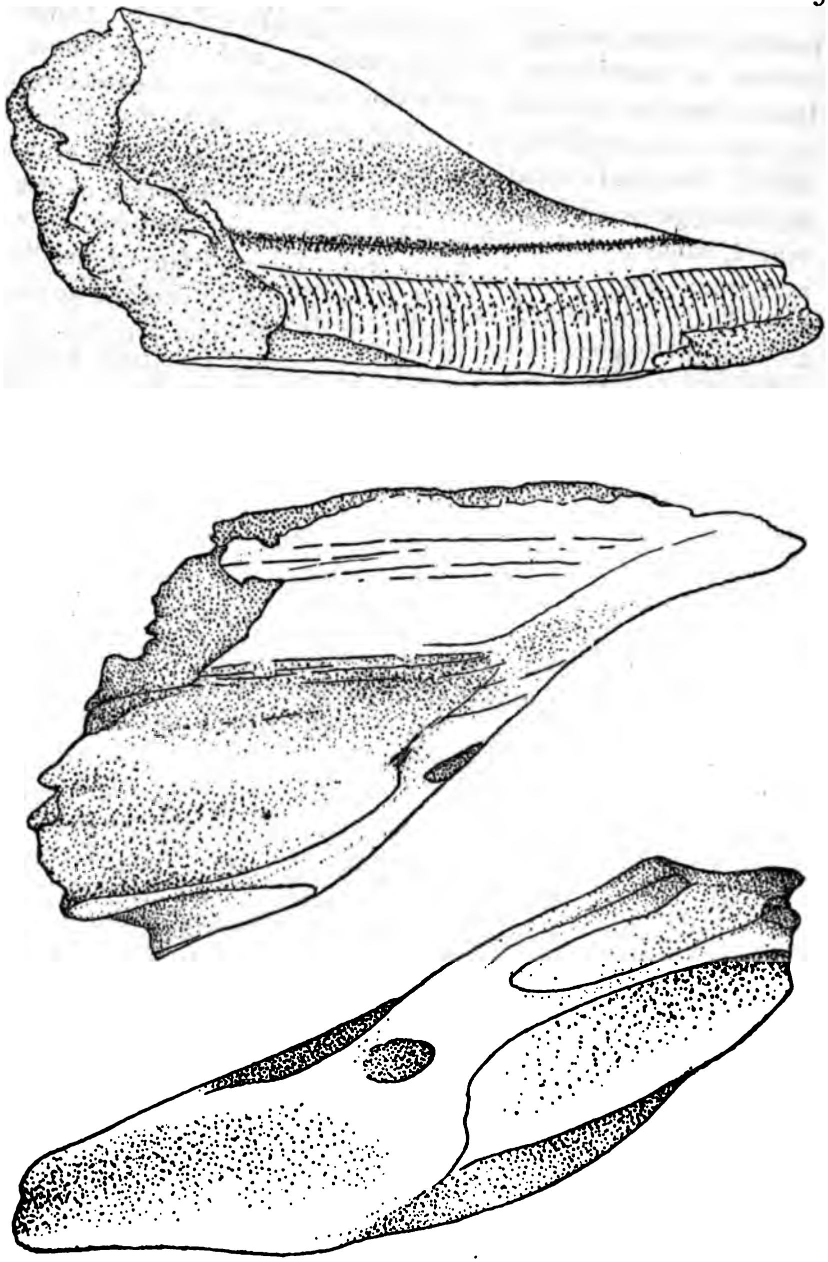

Fig. 76.—*Edaphodon divaricatus* (Cope). (Type.)

isoceles triangle, ending in a moderate symphyseal beak. Outer surface of mandibular concave medianly and convex above (below damaged). Outer profile concave anteriorly, then sloping up somewhat undulated and ending above convexly, below and behind (damaged) apparently more or less convex. Inner symphyseal edge beveled rather short and deep and flattened, except behind, where a slight convex ridge projects and continued back as a groove along posterior inner edge. Inner surface of mandibular below and behind symphysis very slightly concave above and equally convex below, with several indistinct longitudinal striæ. Oral surface of beak well concave and posteriorly forms plane sloping slightly inwards, equally slightly convex, edges not elevated externally. Inner dental area largest, comprising whole inner posterior surface, extending forward slightly before anterior dental surface as sharp angle along inner edge, and forming deep undulation or loop just below anterior outer dental area. Latter smallest of dental areas, rounded, and placed on comparatively level surface. Posterior outer dental area much longer than anterior, close to edge, elongated and still closer to inner dental area, only separated by a narrow level area. Lower surface of mandibular exposing rather broad longitudinal area marked with numerous even broadly lunate striæ. Length 115 mm.

Only the type described above have I been able to examine. Cope had three other examples besides the type from Greensand No. 5, near Hornerstown, in Monmouth County. He notes that they showed the general peculiarities, as interrupted masticatory surface, small external areas, anterior subround and opposite or behind apex of very large inner. Narrowed beak forms an angle with posterior part of jaw and penetrated by a laminar column of little width.

Formation and locality. This species is recorded as from the Cretaceous marls of Burlington County and near Hornerstown in Greensand No. 5. It is tentatively referred to the Hornerstown marl.

EDAPHODON SOLIDULUS (Cope).

Ischyodus solidulus Cope, Proc. Am. Philos. Soc. Phila., XI, 1867, p. 244. *Hornerstown, Monmouth Co., N. J. Greensand No. 5.*
Diphrissa solidula Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 283. (Hornerstown, N. J. Greensand No. 5.)
Edaphodon solidulus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39, Pl. 2, figs. 1-2 (type).

Mandibular compressed, rather deep, or depth about half its length. No distinct external crests. Terminal area of beak forms round extremity of a narrow column. Inner and outer margins, anterior to large area, of equal elevation, regularly curved outwards without angulation. No anterior outer den-

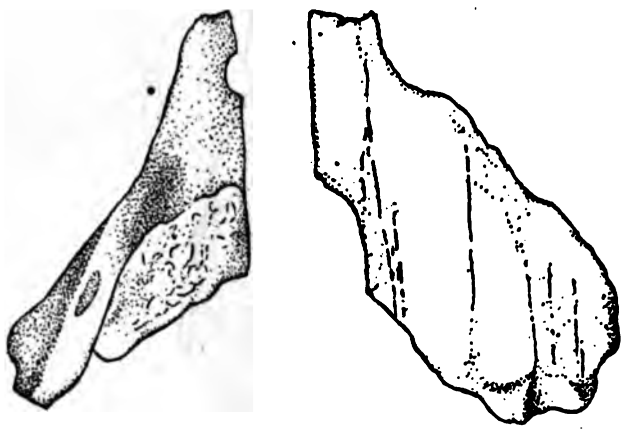

FIG. 77.—*Edaphodon solidulus* (Cope). (Type, from Hussakof.)

tinal area. Posterior outer dentinal area very small and faces inwards from gradual elevation of outer superior margin. Inner area very large, undivided, accompanied on inner margin by a slender column which issues in posterior corner of symphyseal plane. Length (restored) about 64 mm. (From Cope.)

This species was made the basis of a separate genus by Cope. The large inner area of dentinal tubules, with a terminal one issuing near the apex, and only a single small external dentinal area were the chief characters he advanced. However, I accept Hay's action in merging *Diphrissa* with *Edaphodon*.

Formation and locality. Known only from the type, a left mandibular, from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County (J. G. Miers) now in the American Museum at New York.

EDAPHODON LATIDENS (Cope).

Diphrissa latidens Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 283. *Greensand of New Jersey, No. 5.*

Edaphodon latidens Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38, fig. 15 (type).

FIG. 78.—*Edaphodon latidens* (Cope). (Type, from Hussakof.)

Mandibular with anterior portion of beak narrowed, apical area flat or crescent-like. Inner area very wide, leaving but narrow border on outer side. This band but little oblique, edge slightly elevated and without any dentinal area. Single outer column issues near border, hind edge in transverse line with anterior edge of inner area, its front end extending short distance beyond. Anterior border of inner area broad and obtuse. Length 94 mm. (From Cope.)

Formation and locality. Only known from an imperfect mandibular ascribed to the "Greensand of New Jersey No. 5" [the Hornerstown marl, K.] and now in the American Museum at New York.

EDAPHODON sp.

Right palatal depressed, a trifle more than twice as long as wide, and depth about one-third length. Upper surface with a deep wide gutter ending in a deep pit, anterior to which area is flattened and horizontal. Side flattened and sloping obliquely out. Lower surface with conspicuous prominence in front or crest,

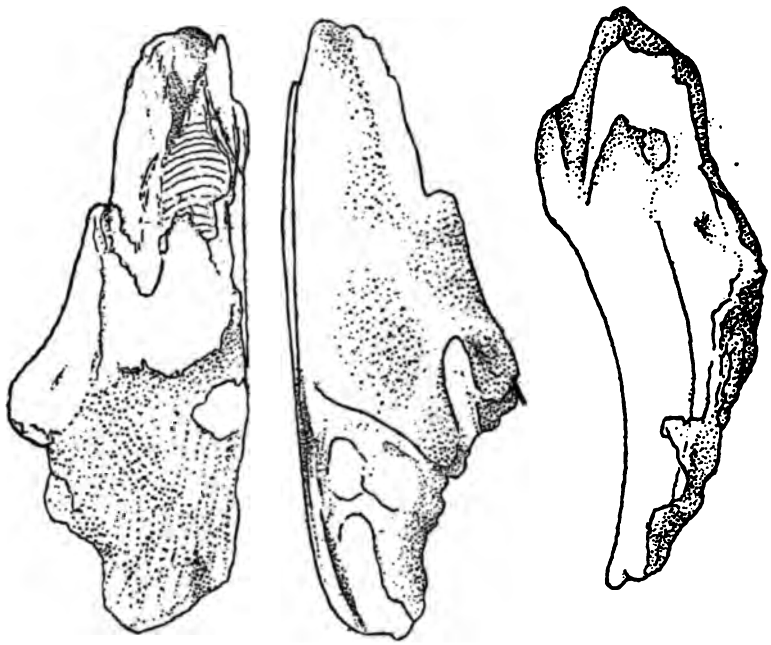

FIG. 79.—*Edaphodon sp.* New Jersey "greensand."

sloping steeply forward. Apex of crest gives rise to anterior dental area, latter elongated, scarcely wider posteriorly, though at that point deeply concave, and extending slightly behind front of inner posterior dental area. External posterior dental area arises very slightly behind front end of posterior inner dental area. Inner surface of upper maxillary entirely flat. Length 70 mm.

I have but the single example, fragmentary, described above. It somewhat resembles the palatal of *E. mirificus,* except that the anterior dental areas are much longer and arise on a much higher crest.

Formation and locality. Recorded only as "from the Greensand of New Jersey."

EDAPHODON sp.

Mandibular bone, right ramus, a trifle more than twice as long as deep, and width a little more than a third its length, so that rami would converge nearly in a triangle, ending in a short, deep symphyseal beak. Outer surface of mandibular generally de-

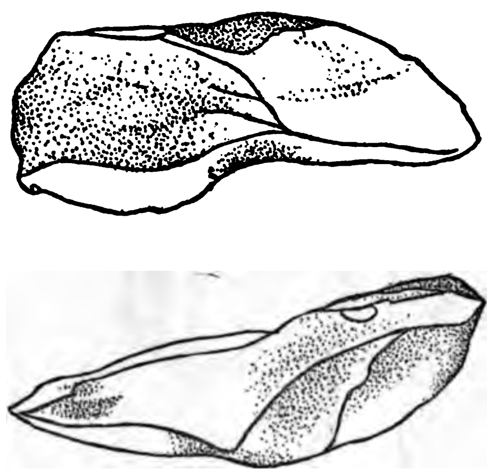

FIG. 80.—*Edaphodon sp.* New Jersey "greensand" (Gabb).

pressed, slightly concave medianly and equally slightly convex above and below. Outer profile undulated slightly anteriorly, arising somewhat convexly behind above. Lower anterior profile convex, then sloping up posteriorly and hind profile vertically convex. No beveled symphyseal edge, though anteriorly well depressed or flattened, then surface rather convex, and flaring slightly, more so inward, behind. Oral surface well marked by lateral edges, though these scarcely prominent ridges, except slightly at anterior symphyseal region and posterior ex-

ternal. Front region of oral surface, near symphysis, and about midway in its length or opposite front of inner dental area, distinct concavities. Inner dental area extends forward slightly before middle in length along inner edge and externally well towards outer edge. Below anterior symphyseal region traces of parallel striæ transversely. Lower surface of mandibular largely convex. Length 63 mm.

Besides the above fragment another with same data seems to resemble the posterior or outer flange of the palatal of *E. mirificus*.

Formation and locality. I have two fragments "from the Greensand of New Jersey" (W. M. Gabb).

Edaphodon sp.

Mandibular bone, right ramus (hind end largely broken away) about half long as deep, and rami probably well diverging behind. Symphyseal plain, moderate, distinct. Outer mandibular surface generally depressed, somewhat concavely. Inner dentinal area large, and apparently begins a little behind outer, though latter but imperfectly preserved. Length about 68 mm.

The above fragment is in the collection of the Geological Survey and is without data, though, like the next, was most likely from the Cretaceous of New Jersey. Similarly it suggests *E. incrassatus,* but is too imperfect for satisfactory comparison.

Formation and locality. Not given.

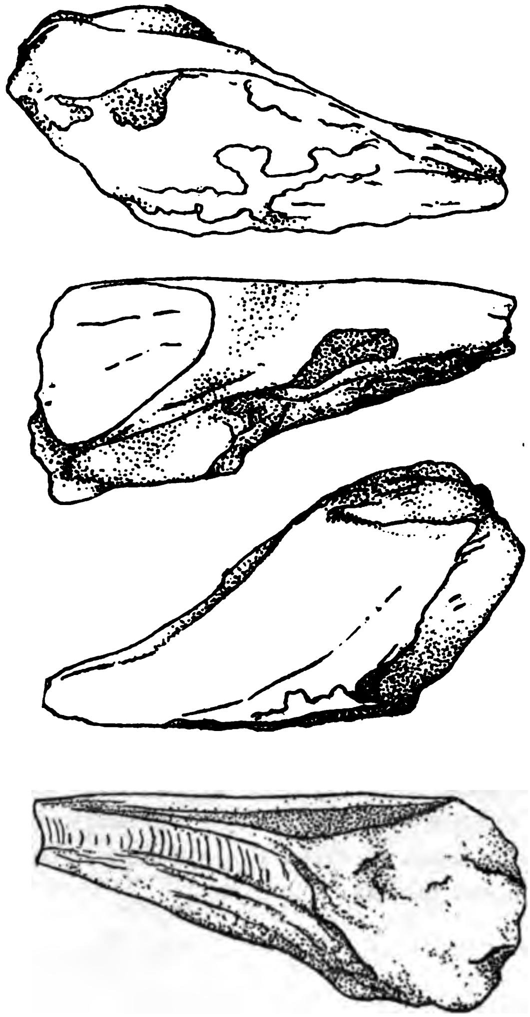

FIG. 81.—*Edaphodon sp.* *New Jersey.

EDAPHODON sp.

Mandibular bone, right ramus (probably half broken away trifle more than half deep as long, and width similar, and ra probably slightly diverging. Symphyseal plane moderate, c tinct. Outer mandibular surface generally depressed. In dental area (only anterior portion remains) extends to in

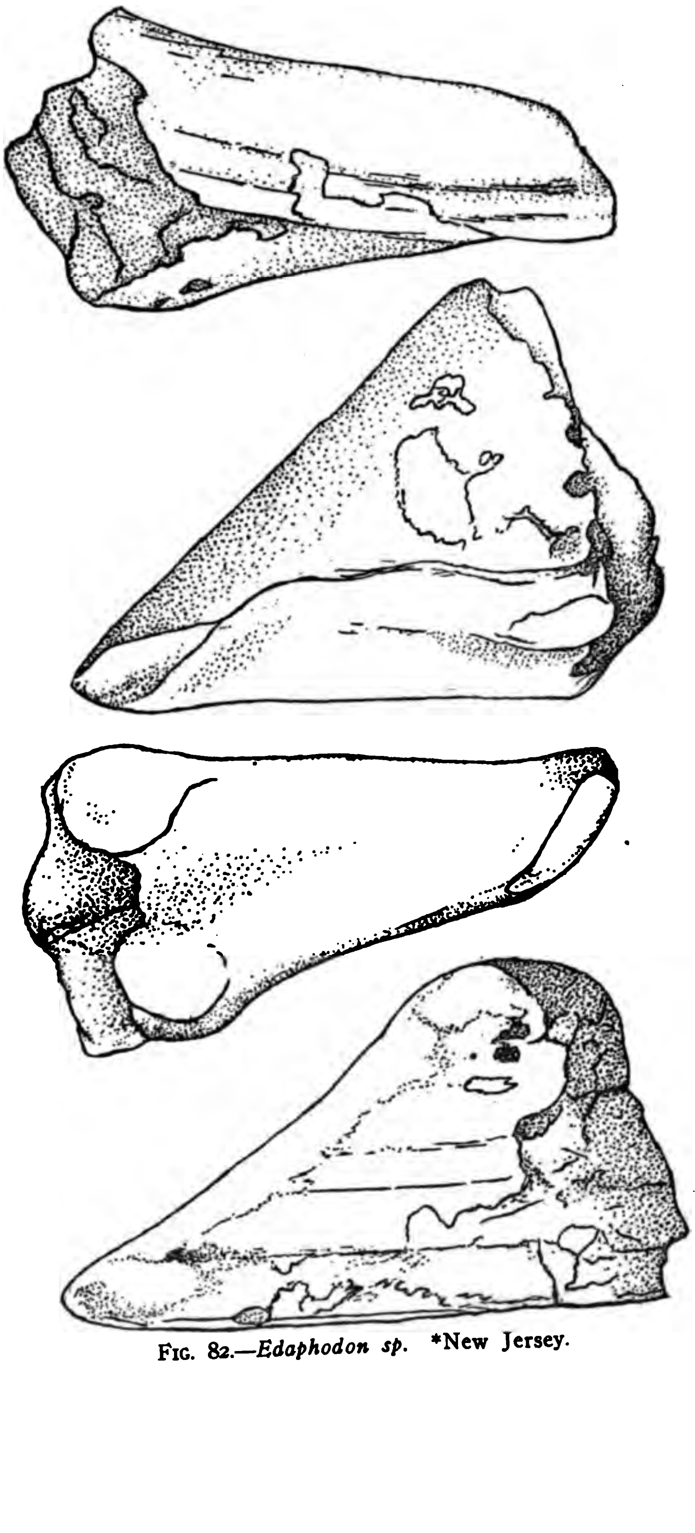

FIG. 82.—*Edaphodon sp.* *New Jersey.

mandibular edge, and in front begins slightly behind outer dentinal area. Latter similar, and apparently large. Length about 80 mm.

This fragment is in the collection of the Geological Survey and is without data. It suggests *E. incrassatus* and may be identical or referable to some similar species as yet undescribed.

Formation and locality. Not given.

Genus BRYACTINUS Cope.

Bryactinus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282. Type *Bryactinus amorphus* Cope, monotypic.

This genus differs from *Edaphodon* in having several dentinal areas exposed along outer edges, the apical tube exposed at both extremities and the excavation of posterior half of inner face.

A single extinct species known.

Bryactinus amorphus Cope.

Bryactinus amorphus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282, Pl. 45, fig. 12. *Hornerstown, N. J. Greensand of No. 5.*
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 37, fig. b (type).

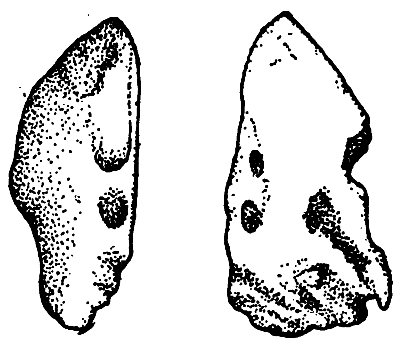

Fig. 83.—*Bryactinus amorphus* Cope. (Type, from Hussakof.)

Dental plate triangular, base representing grinding face, not level, but like others slightly convex. Opposite angular ridge only extends half jaw length, then sinks and exposes hind end of apical column of dentine. On grinding surface along outer border three other columns issue, not parallel in their courses, but

divergent from nearer origins. Inner face behind posterior exit of apical column excavated, possibly for application of another bone. Grinding face convex at middle, divided into two planes behind, outer narrow and elevated, and inner oblique and separated by an obtuse angle from excavation of inner side. Length 42 mm. (From Cope.)

Formation and locality. Known only from the type described above, from the "Greensand No. 5" [Hornerstown marl, K.] of Hornerstown, N. J., and now in the American Museum at New York. I have not seen this example.

Genus ISOTÆNIA Cope.

Isotænia Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. Type *Isotænia neocæsariensis* Cope, monotypic.

Differs from *Edaphodon* in lacking superior groove. Representing two anterior dentinal columns of the latter are two similar exposures, both on same plane and masticatory face together, only separated by a narrow partition.

A single species, extinct.

Isotænia neocæsariensis Cope.

Isotænia neocæsariensis Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. *Hornerstown, N. J. Greensand No. 5.*

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 41, Pl. 3, figs. 3-4 (type).

Palatal with three solid planes, widest opposite to dentinal columns and parallel, and nearly wide as latter. Lateral planes not parallel with one another, wider forms acute angle with last described and narrower very obtuse angle so as nearly continuous with same, running out into it posteriorly. More vertical side retains same depth throughout. One end of bone rounded and truncate, other end excavated directly at right angles to dentinal areas and then continued as an edentulous plate. Length 93 mm. (From Cope.)

Formation and locality. Known only from the above-described type from "Greensand No. 5" [the Hornerstown marl, K.] at

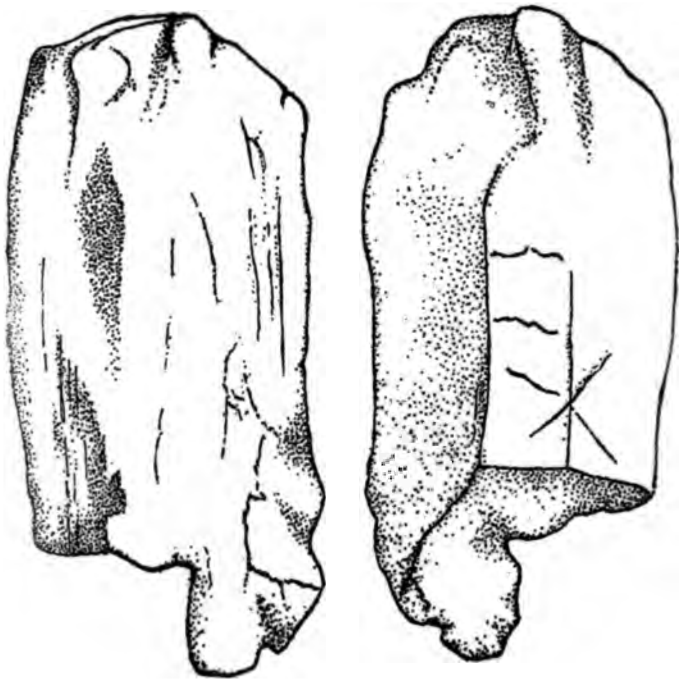

FIG. 84.—*Isotænia neocæsariensis* Cope. (Type, from Hussakof.)

Hornerstown in Monmouth County (J. G. Miers), and now in the American Museum at New York. I have not seen this specimen.

Genus LEPTOMYLUS Cope.

Leptomylus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 313. Type *Leptomylus densus* Cope, monotypic.

This genus is related to *Psaliodus* Egerton,[1] differing in having a single small, narrow dentinal area near the inner margin of the mandibular, which is also without any symphyseal bevel. Median interior longitudinal ridge obtuse and little marked, coated with dense glossy layer.

Species 3, all extinct.

[1] This genus shows no dentinal areas in the mandibulars.

LEPTOMYLUS COOKII Cope.

Leptomylus cookii Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 384. *Near Mount Holly, Burlington Co., N. J. Greensand No. 5.*
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282. (Near Mount Holly, Burlington Co., N. J. Greensand No. 5.)
Leptomylus cooki Hussakof. Bull. Amer. Mus. N. H., XXV, 1908, p. 41, Pl. 2, figs. 8-9 (type).

Mandibular with posterior portion curved out from symphyseal, latter much compressed and moderately prolonged with inner face quite concave, posteriorly outer face also slightly concave. A single obtuse external crest descends gradually to plane

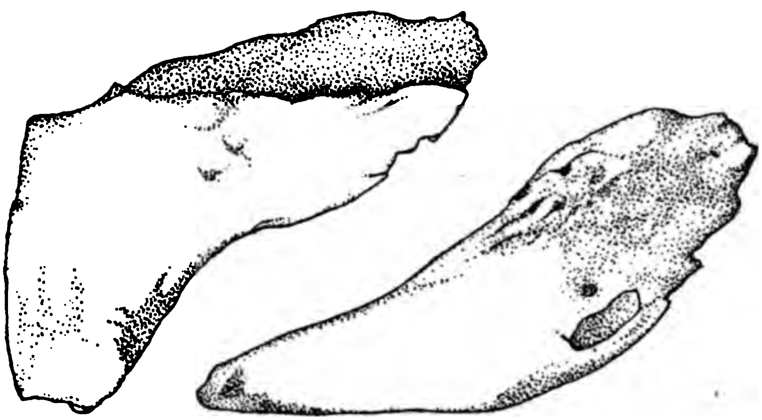

FIG. 85.—*Leptomylus cookii* Cope. (Type, from Hussakof.)

of beak, presenting no dentinal area. A single small oval area represents internal, lies along inner margin and latter much thickened, rolled over inwards and symphyseal face very narrow. End of beak (broken away) in section shows no inferior plate-like column, but a round column, which issues on upper surface of beak behind apex. Length nearly 70 mm. (From Cope.)

Cope says the apical dentinal column distinguished it from *L. densus*, in which no such column exists. He also says at hind fractured section of jaw apical column is seen, while internal dentinal area not, latter occupying only a pocket, not a column. The species is like *Edaphodon solidulus* in the apical column,

which has same form in both, though two dentinal faces latter possesses are those of true *Edaphodon*.

Formation and locality. Known only from the type, described above, a right mandibular, from the marl near Mount Holly in Burlington County, referred to by Cope as "Greensand No. 5" [but now recognized as the combined Navesink-Hornerstown marl bed, K.] now in the American Museum at New York.

LEPTOMYLUS DENSUS Cope.

Leptomylus densus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 313. *Birmingham, N. J. Cretaceous marl pits.*

Cope, Rep. U. S. Geol. Surv. Terr. II, 1875, p. 281. (Birmingham, N. J. Greensand No. 5.)

Mandibular with front end prolonged, slightly narrowed, hind face plane, and transversely concave longitudinally. When external edge rises internal falls off, and narrow dentinal area directed obliquely upwards and inwards. Inner face, above an anterior thickened margin as deep as prolonged beak, concave, but again convex near superior margin. Marked with obscure curved, coarse lines parallel to hind outer edge. Lower or front edge a contracted ridge, inner plane vertical and upper part of inner face expanding upwards. Dentinal column supporting tubercle large as a goose quill. No other columns. Length from first point about 140 mm. (From Cope.)

Cope also describes a palatal he thinks may belong to this species. It differs from *Edaphodon* in the presence of two very narrow dentinal bands, which are opposite and parallel, one on the outer margin and the other within the inner margin of the bone. Form much depressed and spade-like, superior face scarcely descending regularly to edge. Outer margin expands an inch behind end and beveled off from continued width of upper face, latter showing slight longitudinal striæ. Proximally usual large groove.

Formation and locality. Known only from Cope's account, reproduced above, based on a mandibular from the "Greensand No. 5" [the Navesink-Hornerstown marl bed, K.] of Birmingham in Burlington County (J. Gaskill). Also a supposed palatal, with same data.

LEPTOMYLUS FORFEX Cope.

Leptomylus forfex Cope, Proc. Acad. Nat. Sci. Phila., 1875 (Feb. 9th), p. 19 (nomen nurum). New Jersey Cretaceous.
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 281. *Hornerstown and Barnesborough, N J. Greensand No. 5.*
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 41, Pl. 3, figs. 1-2 (type).

Mandibular much elevated, elevation being confined to outer side which rises as a lamina, causing masticatory face nearly vertical much its length, and but short extent level to apex. Slight marginal swelling where anterior outer dental should be, and an abrupt rise in margin to position occupied in *Edaphodon* by posterior outer area. Inner border of masticating surface parallel to inferior border of jaw except where two converge to apex, here entire face included between them occupied by large symphyseal facet. Inner dentinal area represented by narrow acuminate patch on inner angle of masticatory face opposite tuberosity representing anterior outer. Apical area very narrow, extends same distance along exterior angle of superior face. Length 135 mm. (From Cope.)

Cope also notes that the palatal found in connection with the mandibles of *Edaphodon mirificus* does not pertain to them, and is only inferentially referred to this species. The resemblance to the species is very great. Its oblique superior and outer face greatly extended, while inner narrow and vertical. Usual superior groove present, close to edge of latter. Inferior border quite thin. Only two dentinal areas, these exceedingly small and representing outer and anterior inner of species of *Edaphodon* Length 140 mm.

Formation and locality. Known from the type, described above, from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County (J. C. Miers), now in the American Museum at New York. Cope also had a mandibular and palatal from near Barnsboro in Gloucester County (J. C. Vorhees [probably from the combined Navesink-Hornerstown marl beds, K.].

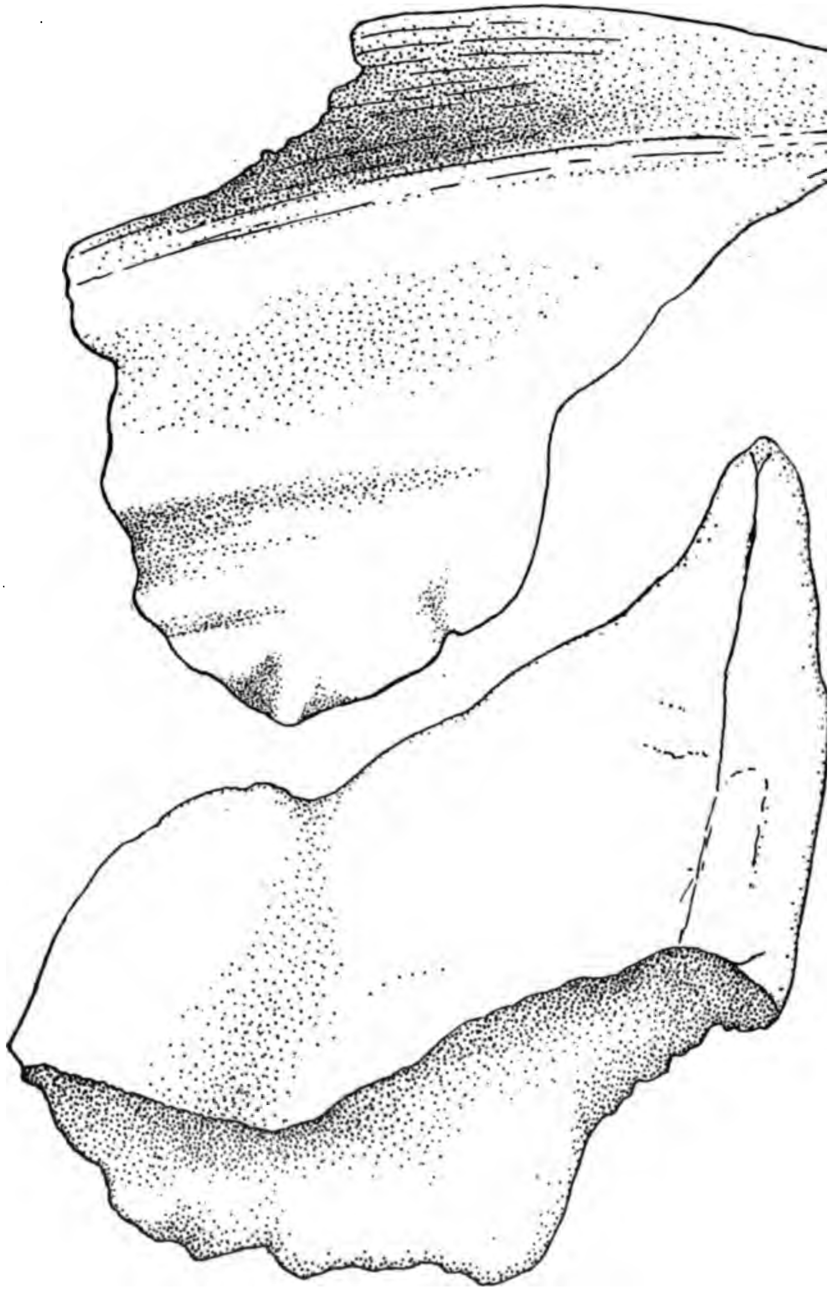

FIG. 86.—*Leptomylus forfex* Cope. (Type, from Hussakof.)

ICHTHYODORULITES.

This group is purely artificial, and is used merely as a repository for various spines, dermal armature, tubercles, etc., of such cartilaginous fishes as sharks and chimæras, which are only known from fragmentary remains. It often follows that such incomplete indications of these animals are very similar in the various genera, and that their determination as to higher rank is very difficult, if not impossible, for which reason it would be convenient to at least indicate them in this provisional arrangement. About 82 genera have been described.

Genus CYLINDRACANTHUS Leidy.

Cylindracanthus Leidy, Proc. Acad. Nat. Sci. Phila., VIII, 1856, p. 12. Type *Cylindracanthus ornatus* Leidy, monotypic.
Cœlorhynchus (nec Giorna) Agassiz, Poiss. Foss., V, 1843, pp. 892. Type *Cœlorhynchus rectus* Agassiz, first species, and name only, restricted by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 331.
Glyptorhynchus Leriche, Poiss. Eoc. Basin Belge, 1906, p. —(not consulted).

Spine very long, slender, gradually tapering, rounded in section, without denticles, external face longitudinally ridged and grooved, each ridge corresponding to wedge-shaped plate which forms small sector of spine. Central cavity relatively small, sometimes in part simple, but usually divided by median partition. Division plane passing through middle of partition, thus allowing spine to be readily split into two symmetrical halves.

This genus was originally thought to be possibly allied with the sword fishes, and others have thought it located near the chimæroids. Its true position must still be considered doubtful.

CYLINDRACANTHUS ORNATUS Leidy.

Cylindracanthus ornatus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 12. *Cretaceous near Pemberton, Burlington Co., N. J.* (W. Taylor), *and Alabama.*
Cœlorhynchus ornatus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 294. (Eocene Marl of Farmingdale, Monmouth Co., N. J.)

Spine cylindrical, slightly tapering (both ends damaged). Surface with longitudinal striæ of more or less even length,

variation in striæ only due to greater width or depth of grooves separating them, and entire surface evenly smooth to touch. As spine narrows occasionally, two will unite and then continue singly. Striæ vary 35 to 45 in number. Length (damaged) 87 mm. Diameter 14 mm.

All the smaller examples exhibit about 35 or 36 striæ, while in the largest there are 45. Allowing for the flutings, which are not over 10, the variation is considerable.

Formation and locality. The types, three fragmentary spines from the "Cretaceous near Pemberton" [may mean the Navesink-Hornerstown marl just west of Pemberton at Birmingham, the Vincentown limesand nearer town, or the Manasquan marl, exposed in the banks of the creek at Pemberton, K.], in Burlington County (W. Taylor), and four small fragmentary spines from the Eocene marl of Farmingdale in Monmouth County (A. J. Smith).

CYLINDRACANTHUS ACUS (Cope).

Cœlorhynchus acus Cope, Proc. Amer. Philos. Soc. Phila., XII, 1870, p. 294. *Eocene Marl of Farmingdale, Monmouth Co., N. J.*
Cylindracanthus acus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 44, fig. 1 (type).

Fragment of small spine with single median cavity, and externally 19 ridges separated by narrow grooves. Length about 29 mm. (From Cope.)

Cope originally states this to be a portion of the muzzle of a fish similar to *C. rectus,* but smaller, also much smaller than *C. ornatus,* and differing from the latter in much fewer ridges.

Formation and locality. The type, described above, from the Eocene marl of Farmingdale in Monmouth County (A. J. Smith), and now in the American Museum at New York.

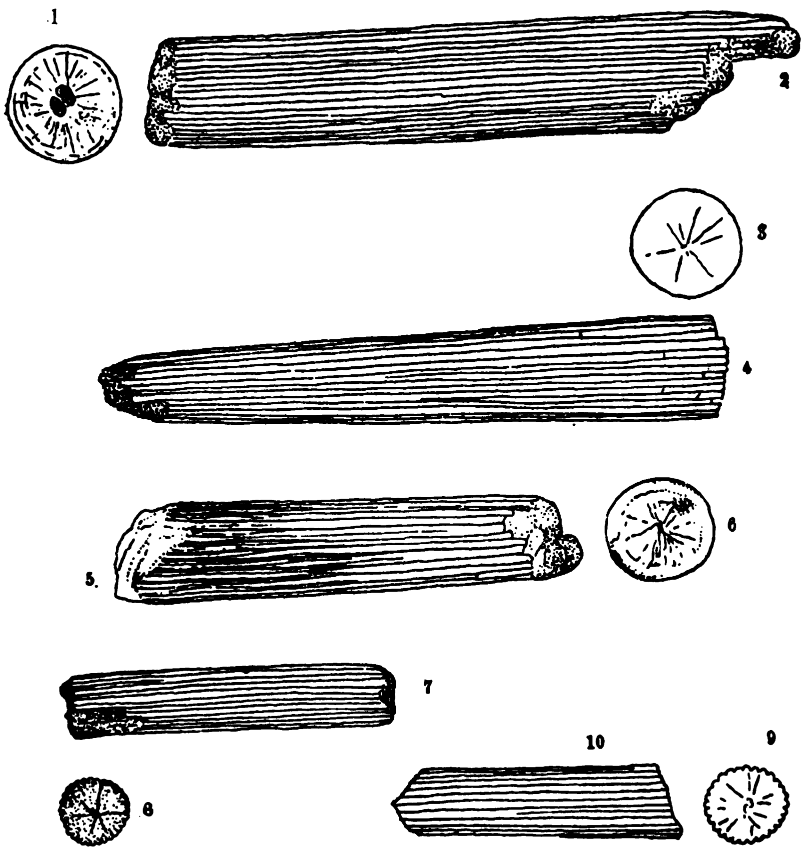

Fig. 87.—*Cylindracanthus ornatus* Leidy. 1–6, New Jersey; 7–10, Monmouth Co.

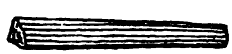

Fig. 88.—*Cylindracanthus acus* Cope. (Type, from Hussakof.)

Genus SPHAGEPŒA Cope.

Sphagepœa Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 241. Type *Sphagepœa aciculata* Cope, virtually designated, monotypic.

Spine slender, acute, nearly straight, with thin projecting anterior edge deeply notched from tip to short distance above base, producing an acute dentition. No teeth behind, but two prominent ridges separated by a deep groove. Sides of spine longitudinally grooved. The single extinct species known.

SPHAGEPŒA ACICULATA Cope.

Sphagepœa aciculata Cope, Proc. Amer. Philos. Phila., XI, 1869, p. 241. *Cretaceous Greensand of the upper bed, Birmingham, N. J.*
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. (Birmingham, N. J. Greensand No. 5.)
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 50, fig. 22 (type).

Spine much compressed in general form, but section of edentulous portion broad as deep. Sides with two elevated ridges, anterior only continued to near tip, gradually broken into series of tubercles near base. Length about 140 mm. (From Cope.)

Cope says this spine may be referred to either a pycnodont, chimæroid or possibly even a plectognath fish. He also adds it resembles the spine of *Microdon nuchalis* figured by Dixon.

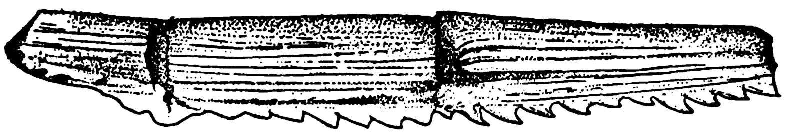

FIG. 89.—*Sphagepœa aciculata* Cope. (Type, ⅔ size, from Hussakof.)

Formation and locality. Known only from the type which Cope says was discovered in the Cretaceous greensand of the upper bed at the pits of the Pemberton Marl Company, Birmingham, in Burlington county (T. Kite). Hussakof, however, gives the locality as Hornerstown. [In either event it seems referable to the Hornerstown marl, K.].

Sub-Class ACTINOPTERI.

THE TRUE FISHES.

Membrane head bones, as opercle, preopercle, etc., developed. Skeleton sometimes cartilaginous, usually bony. Skull with sutures. Lungs imperfectly developed, or degraded to form swim-vessel, or entirely absent. Heart developed, divided into an auricle, ventricle and arterial bulb. Gills with their outer

edges free, their bases attached to bony arches, normally four pairs of these, and fifth pair being typically modified into tooth-bearing lower pharyngeals. Ova small. Median and paired fins developed, latter with distinct rays. No claspers.

Series GANOIDEI.

THE GANOID FISHES.

A scarcely definable assemblage of largely provisional nature first used by Agassiz for those fishes armed with bony plates instead of the usual type of cycloid or ctenoid scales. The orders are: *Lysopteri, Chondrostei, Selachostomi, Pycnodonti, Lepidostei* and *Halecomorphi.*

Order PYCNODONTI.

THE PYCNODONTS.

Notochord persistent, without ossifications in its sheath. Opercle small. Preopercle large. Branchiostegal apparatus reduced. No subopercle or interopercle. No infraclavicles.

This order contains a single family.

Family PYCNODONTIDÆ.

THE PYCNODONTS.

Trunk deeply fusiform or cycloidal. Mouth gape small. Prehensile teeth on premaxillary and dentary, wanting on maxillary (if this bone present) and pterygo-palatine arcade, tritorial on single vomer and splenials, and all teeth without vertical successors. Cranial bones robust, median occipital plate separating parietals. Facial bones delicate or wanting. Opercle reduced till small, preopercle large. Branchiostegals not more than two. Mandibular suspensorium much inclined forward. Notochord persistent, without ossifications in sheath. Scales rhombic when present, frequently wanting on whole or part of caudal region, and almost invariably strengthened by inner rib on anterior edge

and united by peg-and-socket articulation in connection therewith. Fin-rays robust, majority well-spaced and articulated, fulcra absent, except perhaps quite at base of caudal fin. Dorsal and anal more or less extended.

This family, of which all its members are extinct, is apparently most closely related to the sturgeons, near which it has been placed. About 15 genera have been described.

Genus PYCNODUS Agassiz.

Pycnodus Agassiz, Poiss. Foss., II, 1835, p. 183. Type *Zeus platessus* Blainville, first species, restricted by Woodward, Cat. Foss. Fishes, III, 1895, p. 276.

Periodus Agassiz, l. c., p. 201. Type *Periodus hoemigii* Agassiz, monotypic.

Trunk deeply fusiform, gradually passing into slender caudal peduncle. Teeth smooth or with slight apical pit and feeble rugosity. Oral vomerine surface slightly convex from side to side, with five longitudinal series of teeth. Splenial dentition comprising three series of teeth, innermost largest. Head and opercular bones externally rugose and punctate. Neural and hæmal arches of axial skeleton of trunk expanding to encircle notochord. Scales covering front part of body before median fins. Fin rays delicate, spaced, articulated, somewhat divided distally. Pelvic fins present. Dorsal and anal low, fringe-like, former occupies greater part of back and latter much shorter, arising posteriorly. Caudal with slightly excavated hinder border.

About 32 species have been described.

PYCNODUS PHASEOLUS Hay.

Pycnodus phaseolus Hay, Amer. Nat., XXXIII, 1899, p. 788 (name only, based on Leidy).

Pycnodus faba (nec Meyer) Leidy, Rep. U. S. Geol. Surv., I, 1873, pp. 292, 349, Pl. 19, fig. 15-16. *Greensand Marl of Crosswicks, Burlington Co., N. J.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 280. (Greensand No. ? of N. J.)

Jaw fragment with three broad teeth arranged obliquely parallel with one another from within backward and outward. Outline

elongated, bean-shaped, slightly concave in front and convex behind, and slightly wider externally than internally. Length of tooth about 20 mm. (From Leidy.)

The above paratype, figured by Leidy, differs from his type in not having small lateral teeth in at least one series each side of the median, and on one side traces of a second series.

Formation and locality. Originally from the Cretaceous of Mississippi, but also known from Leidy's record of the above-described example from the greensand marl of Crosswicks in

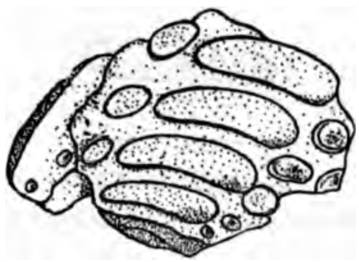

FIG. 90.—*Pycnodus phaseolus* Hay. (Type, from Leidy.)

Burlington County (J. H. Slack). This example was said to have been in the collection of the Academy, but I have not located it. [A marly clay, the Merchantville formation, outcrops at Crosswicks village, but no true marl beds occur within several miles of that place. The Navesink marl was formerly dug along Crosswicks Creek, south of Walnford, and 6 or 7 miles above Crosswicks village. It is impossible to determine whether the specimen is referable to the Merchantville clay or to the Navesink marl, probably the latter, K.]

PYCNODUS BOBUSTUS Leidy.

Pycnodus robustus Leidy, Proc. Acad. Nat. Sci. Phila., 1857, p. 168. *Greensand of New Jersey.*
  Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, pp. 293, 350, Pl. 37, figs. 18–19 (type).

Tooth elongate, rather depressed, slightly convex anteriorly as viewed above, with either end very slightly tapering and rounded. Edges all rounded and like surface smooth. Viewed below

tooth deeply excavated, leaving trenchant edges all around and longer ones slightly more approximated than edges of upper surface. Length about 29 mm.

This was probably inclined from left downward to right end, and beginning at former greater portion beveled as triturating

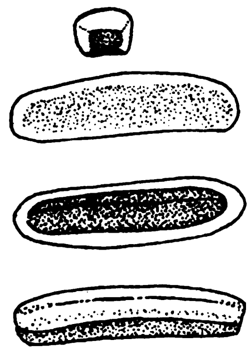

FIG. 91.—*Pycnodus robustus* Leidy. (Type).

surface, leaving lower right portion more convex. Coloration brownish and all about edges rather pale slaty.

Formation and locality. Only the type, described above, without definite locality or geological horizon (G. H. Cook) is known. It is now in the collection of the Academy.

Order LEPIDOSTEI.

THE BONY GANOIDS.

Skeleton bony. Subopercle and preopercle present, also coronoid and mesocoracoid. Branchiostegals present. Ventral fins abdominal, with basilar segments rudimentary, as in ordinary fishes. Primary radii of hind limb generally reduced to one rudiment. Optic nerves form chiasma. Intestine with spiral valve. Arterial bulb with several pairs of valves. Air vessel lung-like, cellular, connected, with œsophagus by duct. Skin covered with ganoid or cycloid scales. Tail heterocercal.

Family LEPISOSTEIDÆ.

THE GAR PIKES.

Body elongate, subcylindrical. Jaws mostly elongate, spatulate or beak-like, upper projecting beyond lower. Eyes small. Premaxillary forms most of upper jaw edge. Maxillary transversely divided in several pieces. Lower jaw composed of as many pieces as in reptiles, coronoid present. Both jaws with outer series of small teeth followed by one or two series of large teeth, besides series of small close-set rasp-like teeth on jaws, vomer and palatines. Large jaw teeth of conic form, pointed, striate, placed at right angles to jaw. These teeth resting in rather deep furrow protected on outside by raised border of jaw, on inside by similar ridge, pierced in center by foramen communicating with maxillary canal through which nerves and blood-vessels enter pulp cavity of tooth. Forms of folded dentine layers within teeth peculiar. Pharyngeal teeth rasp-like. Tongue toothless, short, broad, emarginate, set free at tip. Nostrils close to upper jaw tip. Gill-membranes somewhat connected, free from isthmus. Gills 4, slit after fourth. Gill-rakers very short. Pseudobranchiæ present. Branchiostegals 3. Accessory gill on inner side of opercle. Air-vessel cellular, lung-like, somewhat functional. Stomach not cœcal. Pyloric appendages numerous. Intestinal spiral valve rudimentary. Body covered with hard rhombic ganoid scales or plates, imbricated in oblique series extending downward and backward. External skull bones very hard, rugose. Fins with fulcra. Dorsal fin short, rather high, posterior, nearly opposite similar anal. Tail heterocercal, in young produced as filament beyond caudal. Caudal convex. Pectorals and ventrals moderate, few rayed, latter nearly midway between former and anal.

The existing forms are large fishes, chiefly of the fresh waters of North America, referred to one or two genera. Several generic names have been applied to the fragmentary fossil forms, which are here included under *Lepisosteus*. It seems likely that the existing forms are divisable into two genera, of which *Cylindrosteus* may also be maintained.

Genus LEPISOSTEUS Lacépède.

Lepisosteus Lacépède, Hist. Nat. Poiss., V, 1803, p. 330. Type *Lepisosteus gavial* Lacépède, first species, restricted by Jordan and Gilbert, Proc. Acad. Nat. Sci. Phila., 1877, p. 84.

Lepidosteus, auct.

Psallisostonus Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. Type (no species given, except "Esocis species L.") *Esex osseus* Linnæus, affixed by Fowler, Proc. Acad. Nat. Sci. Phila., 1906, p. 81. (Name inadmissible as only a reprint.)

Cylindrosteus Rafinesque, Ich. Ohien., 1820, p. 72. Type *Lepisosteus platostomus* Rafinesque, first species, restricted by Jordan and Gilbert, l. c., p. 87.

Atractosteus Rafinesque, l. c. Type *Lepisosteus ferox* Rafinesque, first species, restricted by Jordan and Gilbert, l. c.

Sarchirus Rafinesque, Journ. Acad. Nat. Sci. Phila., I, pt. 2, 1818, p. 418. Type *Sarchirus vittatus* Rafinesque, monotype.

Pneumatosteus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 242. Type *Pneumatosteus nahunticus* Cope, monotype.

Clastes Cope, Rep. U. S. Geol. Surv. Terr., 1872 (1873), p. 633. Type *Clastes cycliferus* Cope, second species, restricted by Woodward, Cat. Foss. Fishes, III, 1895, p. 445.

Trichiurides Winkler, Arch. Mus. Teyler, IV, 1876, p. 31. Type *Trichiurides sagittidens* Winkler, monotypic.

Characters included in those of the family.

Lepisosteus knieskerni sp. nov.

Detached scale of lateral line unevenly rhomboid in contour of enameled surface, both upper and lower anterior edges slightly concave and upper posterior side longest. Enameled surface with number of minute pores, and median transverse short excavation (evidently a pore of lateral line) about first three-sevenths

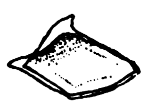

Fig. 92.—*Lepisosteus knieskerni* Fowler. (Type.)

in length of scale. This pore opens on under side of scale in a pore placed about last third in its length, and continued back horizontally as rather deep groove. Inner or lower surface of scale rough, not enameled, with short hook-like process at upper angle. Length about 17 mm.

This species is only known to me from the above-described type, No. 2264, Acad. Nat. Sci. Phila., from Monmouth County, N. J. (Dr. P. D. Knieskern). Unfortunately it is without other data and is accompanied by two small fragmentary bones, one minutely denticulated, possibly belonging to the same animal? This fossil is quite interesting as indicating the first instance of the antiquity of *Lepisosteus* within our limits.

Formation and locality. No formation or definite locality has been given for this species, which would, however, seem to be Cretaceous? (Named for Dr. P. D. Knieskern, who collected the type.)

Order ISOSPONDYLI.

THE ISOSPONDYLOUS FISHES.

Anterior vertebræ simple, unmodified, without auditory ossicles. Symplectic present. Opercles distinct. Pharyngeal bones simple above and below, lower not falciform. Jaw bones developed. Maxillary broad, distinct from premaxillary, forms part of upper jaw edge. No barbels. Shoulder-girdle well developed, connected with cranium by bony post-temporal. No interclavicles. Mesocoracoid arch always well developed, as in ganoids, forming bridge from hypercoracoid to hypocoracoid Gills 4, slit after fourth. Air-vessel, if present, with pneumatic duct. Scales usually cycloid, sometimes ctenoid, occasionally absent. No developed photophores. Dorsal and anal fins without true spines. Adipose fin present or absent. Ventral fins abdominal, sometimes wanting.

A large group, containing about 54 families, some of which show characters analogous in some of the ganoid *Halecomorphi,* seemingly pointing to a possible line of descent. The present order is a very large group, containing a vast number of marine, soft-rayed fishes among living forms, though the fossils are much less numerous.

Family RAPHIOSAURIDÆ.

Dentition with short stout fangs occupying alveoli, of which inner side and part of anterior posterior walls incomplete Teeth

more or less pleurodont, but extremity of root received into conic fundus of alveolus. Premaxillary bones well developed, maxillaries more so, and enter largely into composition of mouth border. Well developed angle of mandible.

This family differs from the *Chirocentridæ* in its dentition. All its species are extinct. Genera about 21. I may note that *Pachyrhizodus* Dixon[1] is antedated by *Raphiosaurus* Owen,[2] and therefore the present family appellation should stand as above rather than as *Pachyrhizodontidæ*.

Genus CONOSAURUS Gibbes.

Conosaurus Gibbes, Smiths. Contrib. Knowl., II, 1851, p. 9. Type *Conosaurus bowmani* Gibbes.

Conosurus, auct.

Conosaurops Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 202. Type *Conosaurus bowmani* Gibbes, virtually, as this name proposed to replace *Conosaurus* believed preoccupied.

Detached teeth conic, in transverse section circular, solid, sharp-pointed, slightly curved backward, fluted near base on inner face with smooth and fine enamel, and with an expanded osseus support.

Only a single species.

CONOSAURUS BOWMANI Gibbes.

Conosaurus bowmani Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 200. (Greensand of Burlington Co.)

Conosaurus bowmanii Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 276. (Greensand of Burlington Co.)

Fragment of jaw slightly compressed, outer surface above less inclined than inner above, also former nearly plane or scarcely convex and latter slightly concave with inclination extending well down. As viewed above fragment slightly convex in general contour. At present three teeth alternate with four deep alveoli, latter appear as slightly ellipsoid pits of rather large size when

[1] Geol. Sussex, 1850, p. 374.

[2] Rep. Brit. Assoc. Adv. Sci., 1841 (1842), pp. 145, 190.

viewed from above. Anterior tooth perfect, inclined slightly back, entirely conical, and tip directed slightly inside. Last two teeth damaged apically, solid, similar to first, and last smallest. Teeth all placed close together. Length 70 mm.

The above example is described by Leidy and referred to this species. Another smaller fragment, similar, only with two teeth, an alveolus between and traces of one externally to each tooth,

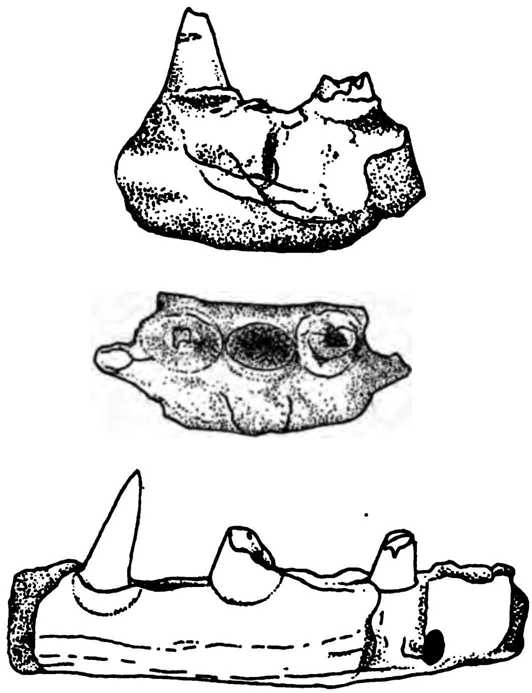

FIG. 93.—*Conosaurus bowmani* Gibbes. Burlington Co. (Taylor).

agrees in having solid conic teeth. In this fragment the external face, apparently, of the jaw, is well inclined. Length about 41 mm.

Formation and locality. The two fragments above described are from the greensand of Burlington County [which are Cretaceous, K.] (W. J. Taylor). The species was originally ascribed to the Eocene of South Carolina.

Family ICHTHYODECTIDÆ.

Body elongate. Snout not produced. Teeth acuminate, almost or exclusively confined to premaxilla, maxilla and dentary bones. Supraoccipital prominent, partly or completely separating parietals in median line. Squamosals reduced, otic region very prominent. Parasphenoid enclosing basicranial canal. Cheek-plates well developed. Mandibular suspensorium inclined forwards, but mouth gape wide. Premaxilla and maxilla robust and firmly fixed, both entering upper mouth border. Opercular apparatus complete, with branchiostegal rays, but no gular plate. Vertebral centra well ossified, none with transverse processes. Ribs nearly or completely encircling abdominal cavity. Hæmal arches more or less fused at base of tail. Intermuscular bones present. Post-temporal bones in contact with postero-lateral angles of cranium. Scales thin, cycloid. Fin-fulcra absent. Fin rays divided and closely articulated distally. Dorsal and anal fins remote, latter elevated into an acuminate lobe anteriorly.

Represented by about eight genera, all extinct. Possibly the most salient character, as distinctive from the *Chirocentridæ* is the anal fin having an elevated anterior lobe.

Genus SAUROCEPHALUS Harlan.

Saurocephalus Harlan, Journ. Acad. Nat. Sci. Phila., III, 1824, p. 337. Type *Saurocephalus lanciformis* Harlan, monotypic.

Saurodon Hays, Trans. Amer. Philos. Soc. Phila., (2) III, 1830, p. 475. Type *Saurodon leæ* Hays, monotypic.

Daptinus Cope, Proc. Acad. Nat. Sci. Phila., 1873, p. 339. Type *Saurocephalus phlebotomus* Cope, specified, monotypic.

Teeth hollow, in sockets, compressed to sharp edge in front and behind. Maxillary and dentary teeth almost uniform, only slightly increasing in size backwards, and those on premaxillary not much enlarged. Successional teeth formed on inner side of functional teeth, and a series of nutritive foramina on inner face of jaw below alveolar border or inner margin of each dental alveolus deeply notched. Small toothless presymphyseal bone

in mandible. Vertebræ about 60 (= 25 + 35). Centra exhibiting two deep longitudinally extended pits on each side.

About 20 species.

SAUROCEPHALUS LEANUS (Hays).

Saurodon leæ Hays, Tr. Amer. Philos. Soc. Phila., (2) III, 1830, p. 476. *Upper Cretaceous of Pensauken Creek.*

Saurodon leanus Hays, l. c., p. 477, Pl. 16, figs. 1–10 (type).

Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 536 (compiled).

Cope, U. S. Geol. Surv. Wyom., 1871, p. 421 (reference).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 255. (Greensand No. 5, N. J.)

Saurocephalus leanus Harlan, Tr. Geol. Soc. Pa., I, pt. 1, 1834, p. 83 (not consulted).

Harlan, Med. Phys. Res., 1835, p. 286 (remarks).

Morton, Amer. Journn. Sci. Art., XXVIII, 1835, p. 277 (name only).

Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 302 (compiled).

Leidy, Tr. Amer. Philos. Soc. Phila., XI, 1857, pp. 91, 94, Pl. 6, figs. 12–15 (largely compiled).

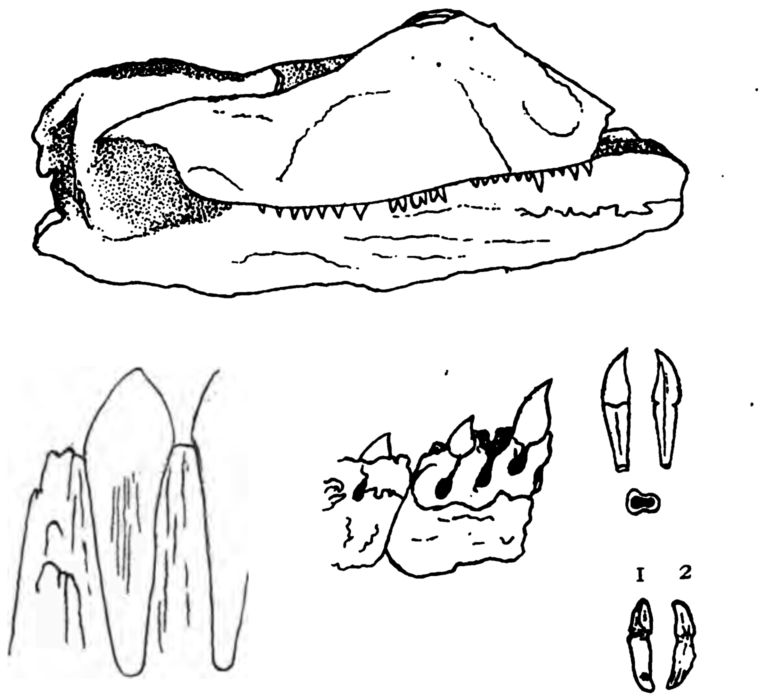

FIG. 94.—*Saurocephalus leanus* (Hays). 1–2, Allowaystown (Yarrow), and others type (from Hays).

Portion of mandible with rami nearly parallel, below through whole extent of fragment in contact apparently united by suture. Posteriorly on each a smooth shallow cavity. Near hind end appearance of suture, most distinct on left side. Dental bone with single row of alveoli continued in front for teeth. Just below alveolar border a series of foramina, one foramen to each alveolus. Teeth of mandible (crushed?) close within upper. Just within dental bone on left side rectangular portion of undetermined bone. Premaxillaries very distinct, united behind by squamous suture to upper maxillary, and apparently lachrymal, anteriorly premaxillaries rounded, and hind portions each side with four or five teeth. A lachrymal between premaxillary and maxillary on each side, deep groove on its front portion passing forward and down becomes smaller as it descends. Each lachrymal with small smooth superficial groove on upper portions, inside small smooth, slightly convex, apparently articulating surface. Maxillary above and in front, near junction with lachrymal, with smooth convex articulating surface inclining little inwards and alveoli for teeth distinct. Near alveolar edge, on inner surface regular series of foramina. Outer surfaces of maxillary and premaxillary with shagreen appearance. Teeth in both jaws close together, uniserial, in distinct alveoli, similar or mandibular rather more compressed, and anterior of latter also smaller than posterior. Crowns of teeth enameled, smooth, lanciform, slightly inclined inwards, and those at hind part of mandible slightly curved forward. Roots hollow, slightly grooved externally, and very slight groove internally. Apparently 9 or 10 intermaxillary teeth and about 30 in each maxillary. Length about 87 mm. (From Hays.)

Formation and locality. The type was found in the upper Cretaceous marl of Pensauken creek 5 miles southeast of Moorestown (J. Brick). [The headwaters of Pensauken Creek originate in the belt of Navesink-Hornerstown marl south of Mount Laurel, so that the specimen may be referred to that horizon, K.] I have not examined any examples unless a detached tooth from the marl at Allowaystown [Miocene, K.] (H. C. Yarrow) is identical.

Family ENCHODONTIDÆ.

Snout not produced. Teeth fused with supporting bone, not in complete sockets, those on pterygo-palatine arcade and dentary largest. Supraoccipital not prominent, but extending forwards to frontals and separating small parietals in median line. Squamosal reduced, only partly covering otic region, which projects laterally. No basicranial canal. Cheek-plates well developed. Mandibular suspensorium vertical or inclined backwards, and mouth gape wide. Premaxilla delicate, considerably extended, and excluding great part of slender maxilla from upper mouth border. Opercular apparatus complete, with few slender branchiostegal rays and no gular plate. Vertebral centra well ossified, none with transverse processes. Ribs not completely encircling adominal cavity. Compound hypural bone at tail base. Intermuscular bones present. Scales delicate or absent, but occasional longitudinal series of scutes and dorsal series, when present, unpaired. Fin fulcra absent. Rayed dorsal never extended much, usually near middle of back, and sometimes an adipose fin behind.

Related to the existing *Evermanellidæ* and *Alepisauridæ*, both fishes of the deep sea. All the members of this family are extinct and comprise about 10 genera.

Genus ENCHODUS Agassiz.

Enchodus Agassiz, Poiss. Foss., V, 1843, p. 64. Type ***Enchodus halcyon*** Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, IV, 1901, p. 191.

Isodus Heckel, Russegger. Reis., III, 1846–49, p. 342. Type ***Isodus sulcatus*** Heckel, monotypic.

Ischyrocephalus Marck, Zeitsch. Deutsch. Geol. Ges., X, 1858, p. 248. Type ***Ischyrocephalus gracilis*** Marck, monotypic.

Solenodon Kramberger, Jahrb. Geol. Reichsanst., XXXI, 1881, p. 373. Type ***Solenodon neocomiensis*** Kramberger, first species, restricted by Woodward, l. c., p. 204. (Preoccupied by Brandt 1833.)

Holcodon Kramberger, Rad. Jugoslav. Akad., LXXII, 1885, p. 19. Type ***Saurocephalus? lycodon*** Kner, virtually monotypic.

Euryganthus Davis, Tr. Roy. Dublin Soc., (2) III, 1887, p. 601. Type ***Euryganthus ferox*** Davis, monotypic.

Trunk elongate-fusiform, and, like head, laterally compressed. Mandible little prominent, with inner widely-spaced series of large slender teeth, front largest, also marginal series of minute teeth all nearly or completely solid. Premaxillary in form of vertical lamina, deepest in front, tapering behind, with uniserial small teeth. Maxillary long, slender, either finely toothed or edentulous at oral edge. Palatine thickened, tumid, with only one large tooth fixed at front end. Ectopterygoid robust, with single spaced series of large slender teeth, gradually diminished in size backwards. No teeth barbed. Operculum strengthened on inner side by ridge extending horizontally back from point of suspension. Cranial roof with deep median longitudinal depression, lateral and occipital margins ornamented like other external bones, with ridges and tubercles of ganoine. Branchiostegal rays about 12–16. Vertebræ 40–50, about half caudal. Centra at least long as deep, constricted mesially, and marked with small irregular longitudinal ridges. Rudimentary dermal scutes not overlapping, in single median series between occiput and dorsal and along course of lateral line. Pair of enlarged hook-shaped dermal scutes at base of tail, one on either side of caudal peduncle. All except foremost rays of each fin finely divided distally, but none excessively elongated. No post-clavicular plate. Dorsal and anal large, neither much longer than deep, and former arising much before middle point of trunk, latter also far forwards. Posterior adipose dorsal. Caudal forked, with curved fulcral rays and stout articulated undivided rays at base both above and below. Pectoral large. Ventral much smaller than pectoral, and far forward.

About 30 species have been described.

ENCHODUS FEROX Leidy.

Enchodus ferox Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 397. ***Greensand near Mount Holly, N. J.***

Emmons, Man. Geol. Ed. 2, 1860, p. 214, fig. 182 (no loc.).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 277. (Below Greensand No. 5, New Jersey.)

Hay, Bull. Am. Mus. N. H., XIX, 1903, p. 68, fig. 50 (Cope's material).

Hussakof, Bull. Am. Mus. N. H., XXV, 1908, p. 72 (Cope's material).

Sphyræna Morton, Synop. Organ. Rem. Cret., 1834, p. 32, Pl. 12, fig. 1. (Blue Marl of Monmouth Co.)
Enchodus pressidens Cope, Proc. Am. Philos. Soc. Phila., XI, 1869, p. 241. *Cretaceous Greensand of New Jersey.*
Cope, Rep. U. S. Geo. Surv. Terr., II, 1875, p. 277. (Greensand No. ? of N. J.)

Fragment of left premaxillary with base of anterior tooth (damaged). Length 38 mm.

Tooth (damaged) compressed laterally, forming rather broad longitudinal concave groove each side, and constricted convex surface with numerous fine parallel vertical basal striæ. Broad expanded convex surface smooth. Entire cutting-edges sharp. Crown of this tooth tapering rapidly to broad compressed and finally sharp point. Base of crown slightly flaring a little behind. Length 36 mm.

Another tooth comparatively broader, without striæ, form more compressed so convex side faces assymmetrical laterally. This tooth also shows very minute serræ along its cutting-edge. Length 38 mm.

The above examples are described in detail as they are Morton's originals. This species is the most abundant of the genus within our limits. It seems to be charâcterized by the cutting-edges of the large teeth extending both sides basally.

Formation and locality. Besides the above-described examples, ascribed to the "Blue marl of Monmouth County" [either Navesink or the Shark River, probably the former, K.] (3); a large fang and portion of attachment from "the Greensand at Freehold in Monmouth County" [Navesink marl] (J. H. Slack 1); also portion of jaw with three large conic teeth without other locality than New Jersey (C. C. Abbott 1); portion of jaw and its attachment labeled New Jersey, and fragment of jaw with two large solid teeth and a series of externals of small size from Burlington County. The following detached teeth seem to belong to this species: 1 of moderate size found with *Hadrosaurus foulkii* at Haddonfield [in the Woodbury clay, K.]; 1 from "New Jersey" (C. C. Abbott); 1 from "New Jersey" (E. D. Cope); 1 from the Cretaceous of "New Jersey" (J. Leidy); 1 imperfect from Monmouth County (C. C. Abbott); 1 from Vincentown in Bur-

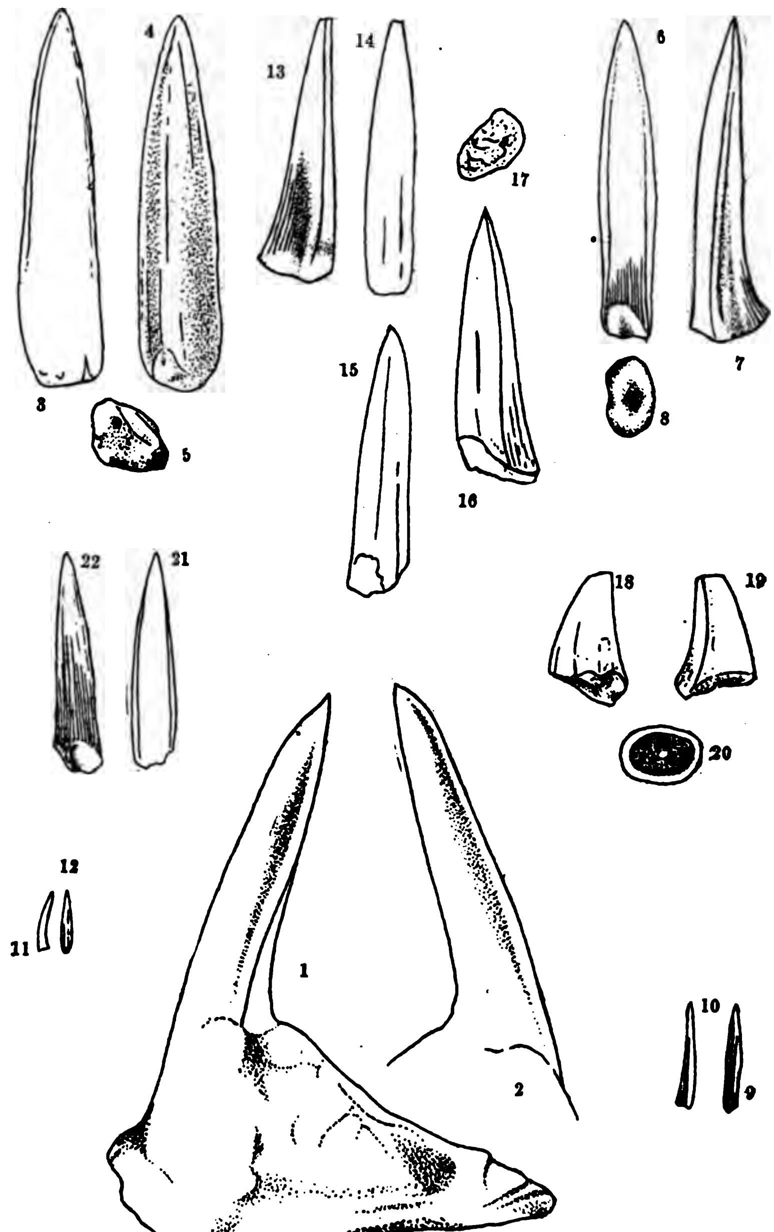

FIG. 95.—*Enchodus ferox* Leidy. 1–2, New Jersey "greensand (Slack); 3–5, New Jersey (Abbott); 6–8, New Jersey (Cope); 9–12, New Jersey (Leidy); 13–17, Monmouth Co. (Morton); 18–20, Monmouth Co. (Abbott); 21–22, Haddonfield.

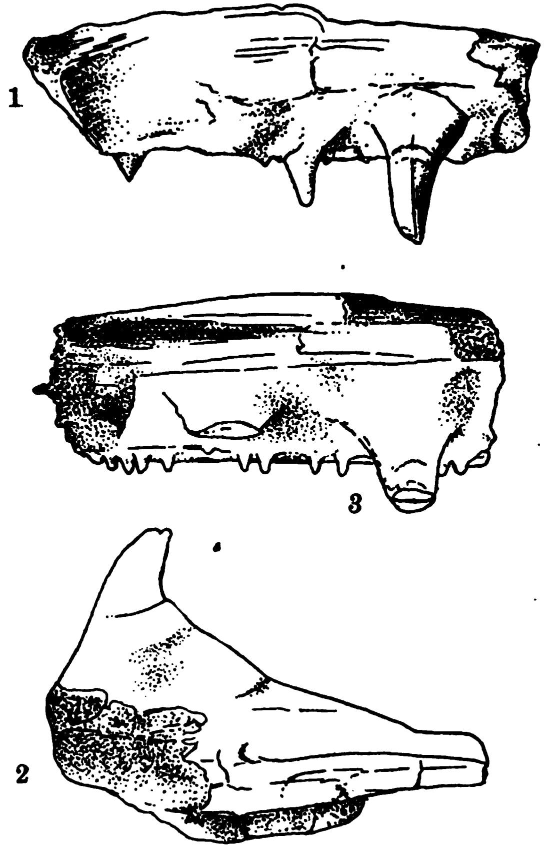

FIG. 96.—*Enchodus ferox* Leidy. 1, New Jersey (Abbott); 2, New Jersey; 3, Burlington Co.

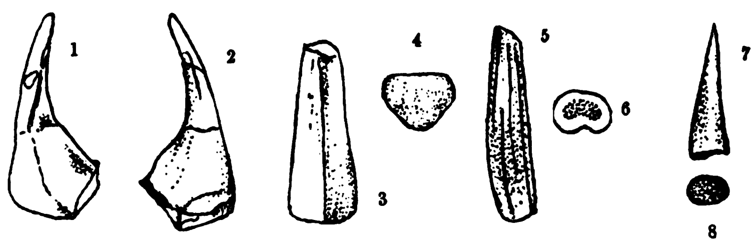

FIG. 97.—*Enchodus ferox* Leidy. *1–6, one mile southwest of Farmingdale in Manasquan Marl; *7–8, near Crawford's Corner in Wenonah sand.

lington County [Manasquan marl or the Vincentown limesand, K.] (T. M. Bryan). I have allowed *Enchodus pressidens* Cope to fall with this species, as suggested by Hay.

ENCHODUS SEMISTRIATUS Marsh.

Enchodus semistriatus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869 (1870), p. 230. *Lower Cretaceous Marl Bed of New Jersey.*
Phasganodus semistriatus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 277. (Greensand of No. 4, New Jersey.)

Tooth slightly sigmoid in shape, compressed, with front sharp cutting-edge minutely denticulated. Rounded posterior surface marked by delicate striæ, except near apex, which latter is furnished with a barb. Length about 23 mm. (From Marsh.)

Marsh also identified some smaller teeth more nearly straight, but apparently without the apical barb.

Formation and locality. Known from detached teeth from the "lower Cretaceous marl bed of New Jersey" [probably meaning the Navesink marl bed, K.].

ENCHODUS SERRULATUS sp. nov.

Tooth somewhat sigmoid in form, well compressed, and front cutting-edge sharp, very finely serrated. Convex posterior sur-

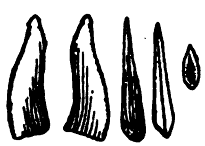

FIG. 98.—*Enchodus serrulatus* Fowler. (Type.)

face with many fine longitudinal basal striæ, not reaching apex or cutting-edge. No distinct barb, but apex with entire cutting-edges, posterior extending below short distance as minutely serrated edge. Striæ quite deep and distinct on basal part of crown. Length 16 mm.

Formation and locality. A single tooth, without formation, from Vincentown in Burlington County [the Manasquan marl, K.] (T. M. Bryan). This example approaches *E. semistriatus*, but differs in its posterior serrated apical keel, the apex itself being entire. Type No. 5,866. Academy of Natural Sciences of Philadelphia.

(*Serrulatus*, with little serræ.)

ENCHODUS GENTRYI (Cope).

Phasganodus gentryi Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. *Miocene of Cumberland Co., N. J.*
Enchodus gentryi Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 72 (type).

Long tooth of jaw anteriorly slender, curved back, front view shows cutting-edge from apex to base and no cutting-edge or angle on posterior face (unless at damaged apex). On one side cementum smooth, on other and posteriorly crown keeled-striate from base to near apex. Length 10 mm. (From Cope.)

This species seems to be distinguished by having a single cutting-edge on the large front teeth in the jaw.

Formation and locality. Known only from the type now in the American Museum at New York. It was from the Miocene [the Kirkwood formation, K.] at Shiloh in Cumberland County. I have not seen any material.

ENCHODUS TETRÆCUS Cope.

Enchodus tetræcus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 278. *Cretaceous No. 4, Delaware and New Jersey.*
Hay, Bull. Amer. Mus. Nat. Hist., XIX, 103, p. 74, figs. 54-55 (types).
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 73 (note on types).

Elongate anterior teeth narrow and slender, greatest basal diameter at right angles to upper part of crown. Posterior side, as usual, much more convex than anterior, two faces separated by

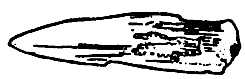

FIG. 99.—*Enchodus tetræcus* Cope. (Type, from Hay.)

cutting-edges, both of which extend to base of crown. Shallow groove runs just behind each cutting-edge to base, giving latter an unsymmetrical figure 8 form of section. Anterior face but little convex, perfectly smooth and posterior very convex, marked with sharply defined grooves about half way to apex from base between lateral shallow grooves. Fifteen may be counted from side to side. Length of crown 30 mm. (From Cope.)

Formation and locality. Known from various teeth, the type a palatine tooth, in the collection of the American Museum at New York. It is from the "Cretaceous No. 4" at St. Georges, Delaware, though Cope also had other material from the same horizon in New Jersey. Not seen by me.

Enchodus oxytomus Cope.

Enchodus oxytomus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 278.
Clays below Cretaceous, No. 4, N. J.

Long tooth from front extremity of premaxillary or dentary. Differs from other species of the genus in extent to which hind cutting-edge prolongs downward toward base of tooth, nearly equaling in this respect anterior edge. As in all other species of the genus cutting-edges not opposite, and a section of base unsymmetrical. Cementum mostly smooth. Crown rather broad for its length, which is below average of Cretaceous species. (From Cope.)

Only known from the above incompletely described example, originally in the Cope collection.

Formation and locality. Known only from "clays below Cretaceous No. 4." Not seen by me.

Enchodus sp.

Tooth solid, curved, compressed, rounded convexly behind and constricted to sharp cutting-edge in front, and (though imperfect) apparently entire. Crown as viewed from cutting-edge

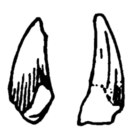

FIG. 100.—*Enchodus sp.* Monmouth Co. (Slack).

deflected convexly to one side, and basally slightly expanded. Each side of base with fine parallel striæ of rather uneven depth, and not extending up more than basal two-fifths. Length 14 mm.

Formation and locality. A single imperfect tooth, with front cutting-edge extending whole length, from Monmouth County (J. H. Slack), without formation.

ENCHODUS SP.

Tooth solid, slightly sigmoid, conic, swelling basally so that transverse section would be deeply elliptical, and apex compressed transversely with lateral keel extending downward each

FIG. 101.—*Enchodus sp.* Monmouth Co. (Knieskern).

side for about two-sevenths length. Edge of each keel under a lens slightly roughened. Surface of tooth entire or smooth, though basally with minute parallel striæ of various perfection. Length 11 mm.

Formation and locality. A small tooth, without formation, from Monmouth County (P. D. Knieskern).

ENCHODUS SP.

Teeth similar to the last except entirely conic, without any keel whatever. Possibly striæ were one time present, but only one example shows basal longitudinal striæ now. All are rather

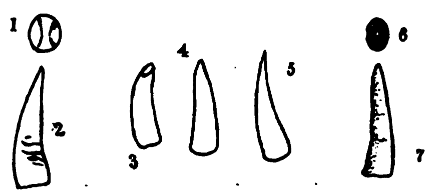

FIG. 102.—*Enchodus sp.* 1–2, New Jersey (Burtt); 3–5, Monmouth Co. (Knieskern); 6–7, Vincentown (Bryan).

compressed basally so as to appear elliptical in transverse section. Length of largest 18 mm.

Formation and locality. Like the last from Monmouth County (P. D. Knieskern) 7. Besides these, also another tooth showing several transverse rings below its middle, from "New Jersey" (Burtt), and one from Vincentown [the Vincentown limesand or the Manasquan marl, K.] in Burlington County (T. M. Bryan).

Order HAPLOMI.

THE PIKE-LIKE FISHES.

Mouth with teeth. Post-temporal normally attached to cranium. Parietals separated by supraoccipital. Symplectic present. Opercular bones well developed. Mescoracoid wanting. Coracoids normal. Hypocoracoid and hypercoracoid separate, with developed actinosts. Pharyngeals distinct, superior directed forward, 3 or 4 in number, lower not falciform. No interclavicles. Scapular arch joined to cranium by post-temporal. Front vertebræ unmodified. Air-vessel with distinct duct. Head usually covered with cycloid scales, like on body. Fins with soft rays. Dorsal low, mostly posterior, first ray occasionally stiff or spine-like. No adipose fin. Pectoral placed low. Ventral abdominal, rarely wanting.

The fishes of this group are interesting as showing osteological characters more in agreement with the *Isospondyli*, thus more or less annectant with that order and the *Acanthopteri*. About six families are known, comprising a number of mostly fresh-water forms among existing fishes. The extinct forms have been referred entirely to the *Esocidæ* and *Pœciliidæ*.

Family ESOCIDÆ.

THE PIKES.

Body elongate, not elevated, more or less compressed posteriorly, broad anteriorly. Head long, snout prolonged and depressed. Mouth large, its cleft forming about half length of head. Upper jaw not protractile, most of its margin formed by maxillaries, which are quite long and provided with a supple-

mental bone. Lower jaw the longer. Premaxillaries, vomer and palatines with broad bands of strong cardiform teeth which are more or less movable. Lower jaw of strong teeth of different sizes. Tongue with a broad band of small teeth. No barbels. Gill-openings very wide. Gill-membranes separate, free from isthmus. Gill-rakers tubercle-like. Pseudobranchiæ glandular, hidden. Branchiostegals 12 to 20. Stomach not cœcal, without pyloric appendages. Air-vessel simple. Basis cranii simple. Head naked above. Cheeks and opercles more or less scaly. Scales small. Lateral line weak, obsolete in young and developed in adult. Dorsal posterior, opposite and similar to anal. No adipose fin. Caudal fin emarginate. Pectoral fins small, inserted low. Ventrals rather posterior.

A single genus, *Esox*, represented by 5 or 6 living species and 4 extinct. I have, however, included *Ischyrhiza* as only provisionally, following Hay's suggestion.

Genus ISCHYRHIZA Leidy.

Ischyrhiza Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. Type *Ischyrhiza mira* Leidy, monotype.

Tooth with crown apparently laterally compressed, conical, covered with smooth shining enamel. Fang more robust than crown, curved pyramidal, quadrate in section, with base rugged and divided antero-posteriorly. Pulp cavity expanded within fang, closed below and narrowing towards crown.

An imperfectly defined genus, known only from detached teeth, though subsequently vertebræ have also been identified as identical. The three species described are extinct.

ISCHYRHIZA MIRA Lediy.

Ischyrhiza mira Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Cretaceous Greensand of Burlington Co., N. J.* (L. T. Germain.)

Leidy, Holmes's Post-pliocene Foss. S. C., 1860, p. 120, Pl. 25, figs. 3-9. (Greensand of New Jersey.)

Cope, Proc. Amer. Philos. Soc. Phila., XII, 1872, p. 355 (name only).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 280. (Greensand, No. 5, New Jersey, near Harrisonville.)

Tooth with crown compressed, elongate, acuminate, with entire keel extending along each edge to base, and transverse section elliptical. Enamel of crown smooth. Root about equal in length to crown, conic continuation of crown apparently, and below hollow. Length 28 mm.

Formation and locality. Originally from the Cretaceous

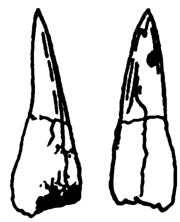

FIG. 103.—*Ischyrhiza mira* Leidy. Haddonfield (Ford).

greensand and No. 5. I have examined a single tooth, described above, in the matrix or Hadrosaurus clay from Haddonfield (J. Ford). [The specimen from Haddonfield is referable to the Woodbury clay; from Harrisonville (Cope) to the Hornerstown marl or Vincentown limesand, K.]

Order ACANTHOPTERI.

THE SPINY RAYED FISHES.

Mouth edge formed by premaxillary. Maxillary normally distinct, always present, sometimes ossified with premaxillary. Shoulder-girdle connected by post-temporal with skull. Post-temporal normally furcate, usually not ossified with skull. Hypercoracoid and hypocoracoid distinct, ossified, former usually perforate. No mesocoracoid or interclavicles so far as known. Pharyngeals well developed, lower rarely united, third upper largest, fourth often absent. Opercular apparatus complete. Front vertebræ unmodified, without ossicula auditus. Gill-opening before pectorals. Gills laminated. Air-vessel typically without duct in adult. Scales variable, typically ctenoid. Lateral line usually extends high. Front dorsal and anal rays typically

simple or spinous, and all fin rays often articulate. Pectorals placed above plane of abdomen, actinosts always present. Ventrals mostly anterior, normally attached by pelvis to shoulder-girdle, usually with a spine and five rays, sometimes absent, sometimes without spine or with many rays, or otherwise modified.

The great majority of living fishes belong to this group, represented by usually very incomplete fossils. As it is impossible to limit or define the present assemblage of fishes by any special one or group of characters, not only as comparatively few of these have been examined, and therefore the necessary data is not available, most likely their genetic relations may never be demonstrated, and this is due in large measure to the meager palæontological record. The transition of forms is quite variable from those with characters approaching the *Haplomi* to those more typical of the spiny-rayed series. About 27 sub-orders have been defined.

Sub-Order PERCESOCES

Branchial arches well developed, bones all present except fourth superior branchihyal. Third superior pharyngeal much enlarged. Lower pharyngeals distinct. Scales cycloid. Spinous dorsal usually present. Pectorals elevated, about level with upper hind opercle angle. Ventrals I, 5, abdominal.

About six families, two of which are entirely extinct, have been included in this group. The existing forms mostly fresh-water or shore fishes of small size, though many quite large and voracious.

Family SPHYRÆNIDÆ.

THE BARRACUDAS.

Body elongate, subterete. Head long, pointed, pike-like. Jaws elongate, lower considerably projecting. Upper jaw nonprotractile, its border formed by premaxillaries, behind which are broad maxillaries. Large sharp teeth of unequal size on both jaws and palatines. No teeth on vomer, usually a very strong sharp canine near tip of lower jaw. Opercular bones without

spines or serratures. Gill-openings wide, gill-membranes not united, free from isthmus. Gills 4, a slit behind fourth. Gill-rakers very short or obsolete. Pseudobranchiæ well developed. Branchiostegals 7. First superior pharyngeal not present, second, third and fourth separate, with teeth. Lower pharyngeals separate. Air-vessel large, bifurcate anteriorly. Many pyloric cœca. Vertebræ 24. Body covered with small cycloid scales. Head scaly above on sides. Lateral line well developed, straight. First dorsal over ventrals, of 5 rather stout spines. Second dorsal remote from first dorsal, similar to anal and opposite to it. Caudal forked. Pectorals short, placed in or below line of axis of body. Ventrals I, 5, abdominal, in advance of middle of body.

Usually a single genus, *Sphyræna,* is allowed, but, according to Hay, *Dictyodus* is admitted.

Genus DICTYODUS Owen.

Dictyodus Owen, Rep. Brit. Assoc. Adv. Sci., 1838, p. 142. No species given. Type *Dictyodus destructor* Owen, Cat. Foss. Rept. Pisc. Mus. Roy. Coll. Surg., 1854, p. 161.

Sphyrænodus Agassiz, Poiss. Foss., V, pt. 1, 1844, p. 98. Type *Sphyrænodus priscus* Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, V, 1901, p. 473.

Teeth moderate, compressed, and each side with sharp keel, often finely serrated. Apex sometimes notched.

Scarcely distinguished from *Sphyræna,* and known only from fragmentary jaw and teeth. Only two species, described below. Woodward refers this genus to the *Scombridæ*.

Dictyodus silovianus (Cope).

Sphyrænodus silovianus Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. *Miocene of Cumberland Co., N. J.*

Dictyodus silovianus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 71, fig. 37 (type).

Fragment of jaw with five teeth and alveoli for four others. Jaw compressed and slightly curved, with smooth surface. Teeth subequal, compressed, rather short and acute, without roots, and

at their bases alveolar borders notched. Length of fragment 20 mm. (From Cope.)

Formation and locality. Known only from the above, obtained

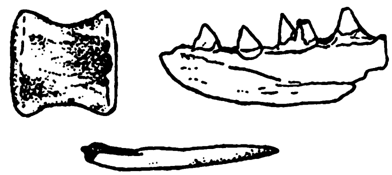

FIG. 104.—*Dictyodus silovianus* (Cope). (Type, x1½, from Hussakof.)

in the Miocene of Cumberland County and now in the American Museum at New York. Not seen by me.

DICTYODUS SPECIOSUS (Leidy).

Sphyræna speciosus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Miocene Marl of Cumberland Co., N. J.* (E. Davis.)
Sphyrænodus speciosus Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Miocene of Cumberland Co., N. J.)

Detached teeth compressed, without roots, inner side much less convex than outer, so that transverse section would be unevenly elliptical, and cutting-edge on each side extending completely from base to apex, and also minutely serrated. Enameled

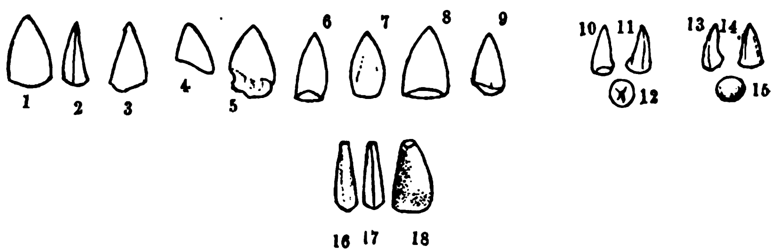

FIG. 105.—*Dictyodus speciosus* (Leidy). 1–9, Monmouth Co. (Knieskern); 10–15, Vincentown (Bryan); 16–18, Charles Co., Md. (Thomas).

surface smooth, without striæ. Anterior tooth shows only single cutting-edge, and though well compressed opposite edge well convex and forming slight apical barb. Basally and around convex edge many minute vertical striæ. Length of largest example 10 mm.

These examples all agree with Leidy's account and strongly suggest the teeth of our existing barracudas.

Formation and locality. Originally from the Miocene marl of Cumberland County, it is very likely my nine examples are from the same formation in Monmouth County (P. D. Knieskern). Cope also had a single anterior tooth from the same formation in the Thomas collection from Charles County, Md.[1] It seems to agree, as much as its fragmentary nature will permit, with the New Jersey material. Also two small teeth from Vincentown [probably the Vincentown limesand or the Manasquan marl, K.] (T. M. Bryan), may also belong to this species, though they are somewhat more curved.

Sub-Order BERYCOIDEI.

THE BERYCOID FISHES.

No suborbital stay. Shoulder-girdle and pharyngeals normal. Vertebræ 24 to 30. Head with conspicuous mucous cavities. Body naked or variously scaled, sometimes scales greatly specialized. Air-vessel with persistent duct in some forms throughout life. Dorsal fin with few or many spines. Ventrals thoracic or subabdominal, each with spine, usually seven branched rays, latter varying five to ten, and in one group spine greatly enlarged, with rays reduced in number.

Usually six families admitted, mostly living fishes in tropical seas, and three are also represented by extinct forms.

Family BERYCIDÆ.

Body oblong or ovate, compressed. Eye lateral, usually large. Mouth wide, oblique. Premaxillaries protractile. Maxillary rather large, usually with supplemental bone. Bands of villiform teeth on jaws and usually on vomer and palatines. Canines sometimes present. Suborbitals narrow, not ensheathing cheeks. Opercular bones usually spinous. No barbels. Gill-rakers mod-

[1] Proc. Acad. Nat. Sci. Phila., 1867, p. 142.

erate. Gills 4, slit after fourth. Pseudobranchiæ present. Gill-membranes separate, free from isthmus. Branchiostegals 7 or 8. Pyloric cœca numerous. Body covered with ctenoid or cycloid scales, foliate or granular. Cheeks and opercles scaly. Head with large muciferous cavities, covered by thin skin. Dorsal fin continuous, spines weak, 2 to 8. Anal spines 2 to 4. Caudal usually forked. Ventrals thoracic, mostly I, 7, number of rays usually greater than I, 5.

Genera about eight, of which three are extinct. Most of the existing forms are bathyic.

Genus BERYX Cuvier.

Beryx Cuvier, Règne Animal, Ed. 2, II, 1829, p. 151. Type *Beryx decadactylus* Cuvier, first species.

Body deep, compressed, abdomen trenchant without enlarged scutes. Head large. Snout short. Eye large. Mouth oblique, mandible end prominent. Both jaws, vomer and palatines with villiform teeth. Opercles serrated. Opercle usually with spine. Preopercle unarmed. Air-vessel simple. Pyloric cœca numerous. Body covered with rather large ctenoid scales regularly arranged. Head with thin bones and high ridges with deep muciferous cavities. Dorsal continuous, with four to six spines. Anal spines 4, rays 26 to 30. Ventrals with about ten articulated rays.

About six fossil species have been described. The existing species are brilliantly colored red and occur in deep water.

BERYX INSCULPTUS Cope.

Beryx insculptus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 240. *Lower Greensand bed of Monmouth Co., N. J. Dark clay marl just below Upper Greensand bed at Hornerstown.*

Cope, l. c., XII, 1872, p. 357 (name only).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 272, Pl. 52, fig. 4 (Greensand No. 5, N. J.)

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 63, fig. 31 (type).

Body stout. Scapular arch and cranium strongly marked with narrow elevated ridges which form a reticulate relief. Scales

large, thick, also large and narrowly exposed below lateral line, where in seven longitudinal series and not less than two above. In lateral line 23 scales, possibly a few more, as point of departure from suprascapula lost and greater part of cranium broken away. Sculpture of scales consists of a series of radiating ridges, whose interspaces are equal to them, and whose extremities project as

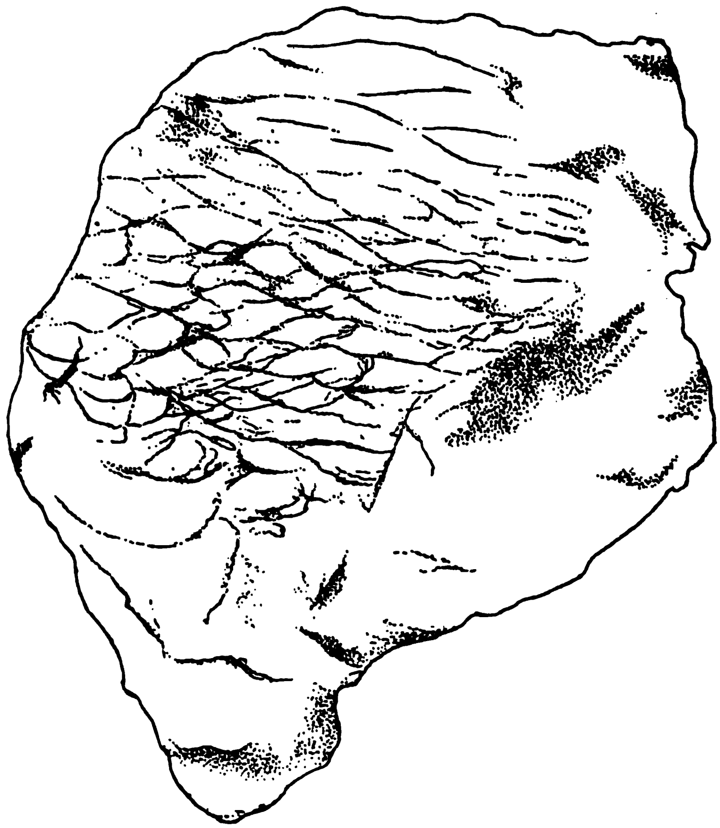

FIG. 106.—*Beryx insculptus* Cope. (Type, from Hussakof.)

short acute points. These ridges interrupted at short distance from middle of exposed surface, forming irregular obtuse elevations, while middle of area divided by shallow grooves into irregular areas. Whole sometimes crossed by one or two shallow interrupted concentric grooves. Tubes of lateral line not extending behind middle of exposed area, acute, with an areolate rugose

surface. Series of small smooth scales continues lateral line to middle of tail. Fins not well preserved, but pectoral radii remain and are of stout proportions. Dorsal and caudal rays very stout. Length about 143 mm. to probably hind margin of pectoral arch. (From Cope.)

Cope has pointed out its distinguishing characters as compared with several European fossil forms.

Formation and locality. Known from part of the trunk, the type now in the American Museum at New York, having been found in the lower greensand [Navesink marl, K.] of Monmouth County (S. Lockwood). Another example was also taken just below the upper greensand in the dark clay marl [Red Bank formation, K.] at Hornerstown, in the same county (J. Meirs), and was in the Marsh collection. I have not seen this species.

Sub-Order PERCOMORPHI.

THE PERCH-LIKE FISHES.

Body variously formed, usually oblong. Head usually compressed laterally. Mouth and dentition various, usually terminal with lateral cleft. Teeth typically pointed in bands on jaws, vomer and palatines. Premaxillary forming mouth edge, usually protractile. Mandibular bones distinct. Opercular bones well developed, normal. Preopercle typically serrate. No cranial spines. No bony stay connects suborbitals with opercle. Gill-rakers various, usually sharp, stout, dentiferous. Gills 4, slit behind last. Pseudobranchiæ typically well developed. Gill-membranes usually separate, sometimes joined, rarely attached to isthmus. Branchiostegals few, usually 6 or 7. Lower pharyngeals mostly separate, usually with cardiform teeth, third upper moderately enlarged, elongate, and not articulated to cranium, and fourth usually present. Air-vessel usually present, without air-duct in adult, simple, generally adheres to abdominal walls. Stomach cœcal, with pyloric appendages. Intestines short in carnivorous forms, long in herbivorous. Shoulder-girdle attached to cranium by distinctly forked post-temporal, not adnate

to cranium or ossified with it. Coracoids normal, hypercoracoid with median foramen. Pectoral actinosts normal, 3 or 4, hour-glass shaped, longer than broad. Vertebræ from 24 to 100, usually numerous in pelagic, extra-tropical and fresh-water forms. Scales variously cycloid, ctenoid, sometimes rough or wanting, also small or large. Lateral line various, generally regularly arched, sometimes wanting. Dorsal fin various, spinous portion usually present, sometimes absent. Anal usually like rayed dorsal, spines present or absent. Caudal usually lunate, various, sometimes absent. Pectorals usually well developed. Ventrals sometimes rudimentary or absent, generally present, thoracic, subjugular or subabdominal, usually with one spine and five or more rays.

This group is apparently somewhat provisional, and does not seem to have been exactly defined, though two series of families have generally been admitted, as the *Scombroidea* and the *Percoidea*, comprising a vast army of living fishes typified by the mackerels and perch, respectively. A few remains have been found in the New Jersey Cretaceous, representatives of each.

Family ISTIOPHORIDÆ.

THE SAIL FISHES.

Body elongate, much compressed. Caudal peduncle with two fleshy crests or keels. Bones of upper jaw consolidated into a sword, which is roundish on edges and spear-like, shorter than in the sword fishes. Teeth in jaws small, persistent and granular. Gills reticulated as in sword fishes. Vertebræ 24, elongate and hour-glass shaped. Neural and hæmal spines flag-like. Ribs well developed. Air-vessel very large, sacculate, of many separate divisions. Intestine short, straight. Body covered with elongate scutes. Dorsal single or divided into 2 contiguous parts, first much longer than second, fin-rays distinct, first rays distinctly spinous. Anal divided. Last dorsal and anal rays suctorial. Ventrals attached to pelvic arch, each with one or two rays.

The recent forms comprise about two genera, and are oceanic or pelagic, resemble the sword fishes, though of smaller size. The fossils, known only from fragmentary rostra, have been referred to the existing *Istiophorus* and two other genera.

Genus ISTIOPHORUS Lacépède.

Istiophorus Lacépède, Hist. Nat. Poiss. III, 1802, pp. 374, 375. Type *Istiophorus gladifer* Lacépède, monotypic.
Histiophorus, auct.
Makaira Lacépède, l. c., IV, 1803, pp. 688, 689. Type *Makaira nigricans* Lacépède, monotypic.
Machæra, Macaria, auct.
Nothistium Hermann, Observ. Zool., 1894, p. 304. Type *Histiophorus americanus* Valenciennes, virtually, as based on *Guebucu* Marcgrave, though no binomial given.
Zanclurus Swainson, Nat. Hist. An., II, 1839, p. 239. Type *Zanclurus indicus* Swainson, monotypic.

Body slender, much compressed. Rostrum usually shorter and less flattened than in sword fishes, edge more rounded, and mandible more developed. Many small teeth on jaws and palatines. Air-vessel sacculate. Intestine short, nearly straight. Body covered with elongate scales, rougher than sword fishes. Dorsal fin very high, continuous, as in young spear fishes and sword fishes, rays numerous, none aborted, first rays much higher than body depth. Anal divided. Ventral present, rays 2 or 3.

The recent forms large fishes of warm seas, the number of species uncertain, likely several, and one recently found on our coast. About six extinct forms.

ISTIOPHORUS ANTIQUUS (Leidy).

Xiphias antiquus Leidy, Proc. Acad. Nat. Sci. Phila., VII., 1855, p. 397. *Greensand of Burlington Co., N. J.* (C. H. Budd.)
Histiophorus antiquus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 310 (reference).

Rostrum well depressed, transversely oval in section, its short diameter about one-half its long diameter, and anteriorly becoming more cylindrical. Length about 265 mm. (From Leidy.)

This was a large species, known only from its rostrum, and especially characterized by its depressed form with the dentary surfaces on one plane.

Formation and locality. Only the type known, described above, from the greensand of Burlington County (C. H. Budd). Not seen by me.

Istiophorus homalorhamphus (Cope).

Histiophorus homalorhamphus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 310. *Eocene or Miocene Greensand near Squankum, N. J.*

Rostrum in general form nearly cylindrical, tapering slightly, depressed above and below, though former surface more so, thus forming wide ovoid in transverse section with lesser diameter one-seventh greater or horizontal at its base. Near end of rostrum vertical diameter but little less that of horizontal. Upper surface evenly convex, and each side slopes down rather evenly below somewhat in a plane, these surfaces approximating toward end of rostrum and intermediate space at first moderately convex, but gradually becoming very constricted. At base two small approximated foramina a little below middle in vertical diameter. Surface of rostrum entirely minutely porous. Length 170 mm.

The examples described above seem to be identical with Cope's. This species differs from *I. antiquus* in its more cylindrical form and having the dentary surfaces on two planes. The following characters are gathered from Cope's account.

Rostrum nearly cylindrical, with a slight depression, transverse diameter exceeding vertical by less than one-eighth of former. Dentigerous inferior bands not separated by a groove, width of each two-thirds lesser diameter, each forms with other a strong obtuse angle and basally flattened, then curved upwards at external margin. Alveolæ numerous, small, 5 in one-tenth of an inch. Base broken, but longer diameter 4⅔ of length. Surface of base not dentigerous, with numerous anastomosing striæ. Length about 110 mm.

Formation and locality. Eocene or Miocene greensand near Squankum in Monmouth County (W. S. Vaux). Only known from the above-described type, an osseous muzzle, and three

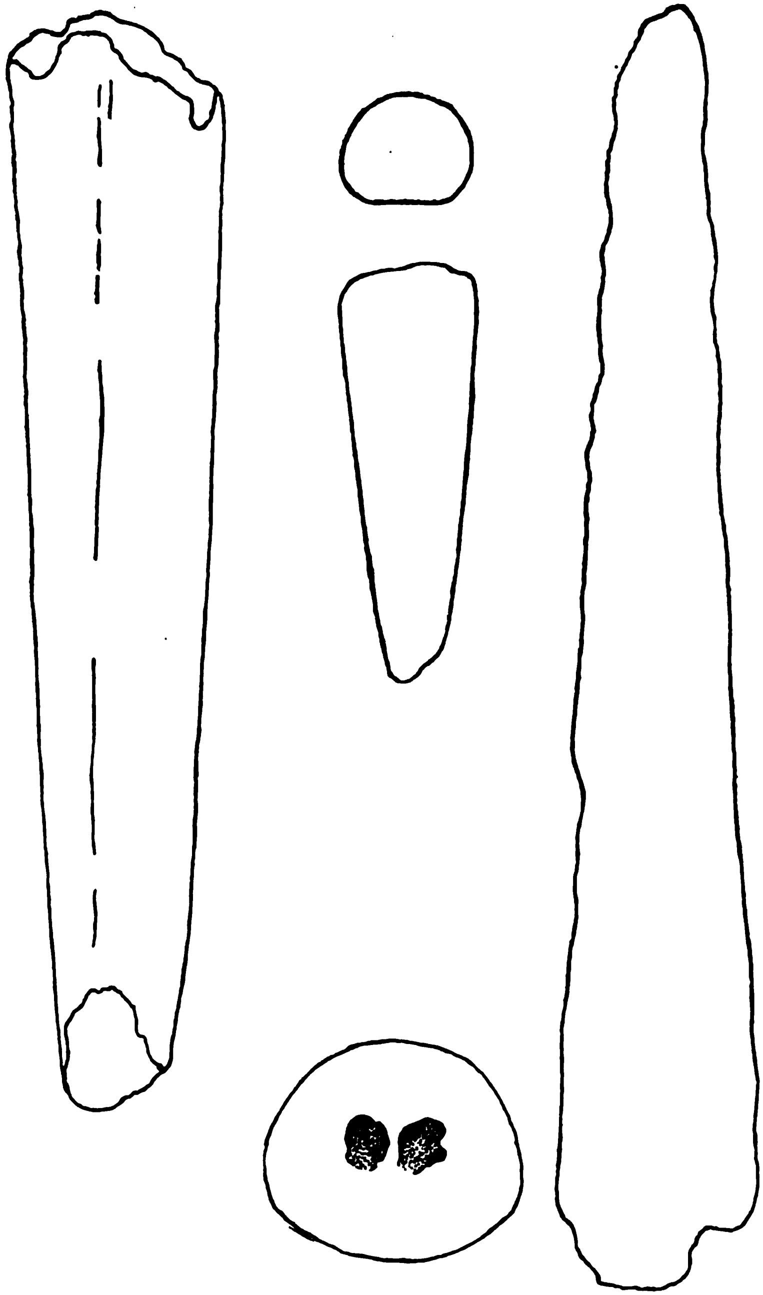

FIG. 107.—*Istiophorus homalorhamphus* (Cope). Vincentown (Bryan).

others from Vincentown [Manasquan marl, K.] in Burlington County (T. M. Bryan).

ISTIOPHORUS PARVULUS (Marsh).

Histiophorus parvulus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 227
Eocene Greensand, Squankum Marl Company, in Monmouth Co.

Rostrum slender, very pointed, compressed transversely, and lower surface nearly flat. Brush-like teeth on this portion reduced to two narrow bands. Remaining surface irregularly striated. Length about 76 mm. (From Marsh.)

Formation and locality. This small species was originally based on the above-described type from the Eocene greensand from the pits of the Squankum Marl Company in Monmouth County (O. B. Kinne), and presented to the Yale Museum. [According to Cook only the Cretaceous marl (the Manasquan) was dug at this company's pits, K.] Not seen by me.

Genus EMBALORHYNCHUS Marsh.

Embalorhynchus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 228. Type *Embalorhynchus kinnei* Marsh, monotype.

According to Marsh this was a small species of sword fish allied with *Cylindracanthus* of the Eocene. The beak resembles in general form that of *Cylindracanthus,* but is much smaller, tapers more rapidly and has its lower surface flattened and marked by two shallow grooves. Like the rostrum of *Cylindracanthus* it has a double cavity at the base and single median one.

One fossil species described.

EMBALORHYNCHUS KINNEI Marsh.

Embalorhynchus kinnei Marsh, Proc. Amer. Ass. Adv. Sci., 1869, p. 228.
Eocene Greensand, Squankum Marl Company, Monmouth Co.

Rostrum small, short, tapering rapidly, inferior surface flattened and marked by two shallow grooves. Base of rostrum with double cavity and single one through median portion of shaft.

Upper surface very delicately fluted. Length about 65 mm. (From Marsh.)

Marsh thought the fish probably did not exceed 15 inches in total length.

Formation and locality. Only the type known, described above, from the "Eocene greensand at the pits of the Squankum Marl Company" in Monmouth Co. (O. B. Kinne). [See comment on preceding specimens, K.] Not seen by me.

Family SPARIDÆ.

THE PORGIES.

Body oblong or more or less elevated. Head large, crests of skull usually largely developed. Mouth small, terminal, low, horizontal. Premaxillaries little protractile. Maxillary short, peculiar in form and in articulation, without supplemental bone and slipping for most part of its length under preorbital edge, which forms more or less distinct sheath. Preorbital usually broad. Teeth strong, those in front of jaws conical, incisor-like or molar. No vomerine or palatine teeth. Hind nostril larger, usually more or less oblong or slit-like. Preopercle entire or serrate. Opercle without spines. Gill-membranes separate, free from isthmus. Gills 4, large slit behind fourth. Gill-rakers moderate. Pseudobranchiæ large. Lower pharyngeals separate. Air-vessel present, usually simple. Pyloric cœca few. Vertebræ usually 24. Intestinal canal short. No suborbital stay. Body covered with rather large adherent scales, never truly ctenoid. Head sides usually scaly. Lateral line well developed, concurrent with back, not extending on caudal. Dorsal fin single, continuous or deeply notched, spines usually strong and depressible in a groove. Dorsal spines heteracanthous, 10 to 13. Anal rather short, similar to rayed dorsal, spines 3. Caudal usually concave. Ventrals I, 5, thoracic, usually with distinct scale-like basal appendage.

The recent genera, about 12, carnivorous shore fishes of tropical seas, most valued as food. Fossils have also been referred to some of these as well as about eight others.

Crommyodus Cope.

Crommyodus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 243. Type *Phacodus irregularis* Cope, virtual designation and monotypic. (*Phacodus* preoccupied.)

Teeth fusiform, irregularly and closely crowded on surface of an elongate semidiscoid bone of possibly hyoid apparatus. Masticatory surface moderately convex. Crown abruptly contracted below into short root, which presents very small orifice for admission of nutrient vessels, etc. Teeth thus somewhat shape of an onion inverted. Pulp cavity large. Superficial layer of crown very thin, its structure not known, but its punctate appearance resembles that of a worn surface of vaso-dentine.

Cope also states the successional teeth as very abundant, and closely placed. They appear to rise through the spongy tissue of the bone without reference to any definite line of succession or superposition. Those of the inferior series, visible on under surface of bone, have an average larger size than those on upper surface which are in use. A single extinct species.

Crommyodus irregularis (Cope).

Phacodus irregularis Cope, Proc. Boston Soc. Nat. Hist., XIV, 1869, p. 33. *Miocene near Shiloh, Cumberland Co., N. J.*

Crommyodus irregularis Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 243 (reference).

Cope, l. c., XIV, 1875, p. 362 (reference).

Teeth, though irregularly arranged for short distances in longitudinal lines, transversely ovate, closely packed or with slight intervals. Those at outer and inner margins of bone considerably smaller than median and more rounded. Crown of successional teeth flattened, as well as those in use. Median teeth number 5 in one-half inch, and lateral 7 in same length. Surface of root finely striate, striæ coarser at point of convergence at orifice of pulp cavity. Crown in many teeth broken away, leaving short conic pulp cavity and its thin walls exposed. Bone convex in transverse direction, descending more gradually on convex margin. Length of bone about 40 mm. (From Cope.)

Formation and locality. Known from the Miocene marl [Kirkwood, K.] near Shiloh in Cumberland County. Not seen by me.

Sub-Order PHARYNGOGNATHI.

THE LABROID FISHES.

Nostrils double. Gills 3½, without slit after last. Lower pharyngeals fully united. Scales weakly ctenoid or cycloid. Dorsal and anal fin spines not very strong. Ventrals thoracic, each with one spine and three rays. Otherwise not differing much from the *Percoidea.*

The existing forms are mostly large tropical fishes, with bright colors and strong dentition. About four families are admitted.

Family LABRIDÆ.

THE WRASSE FISHES.

Body oblong or elongate. Mouth moderate, terminal. Premaxillaries protractile. Maxillaries without supplemental bone, slipping under membranaceous preorbital edge. Front teeth usually very strong, canine-like. Jaw teeth separate or soldered together at base, not forming continuous plate. No vomerine or palatine teeth. Lips thick, longitudinally plicate. Nostrils round, with two openings on each side. Gill-membranes somewhat connected, sometimes joined to narrow isthmus. Gills 3½, slit after last arch, small or obsolete. Pseudobranchiæ well developed. Branchiostegals 5 or 6. Lower pharyngeals completely united into one bone, without median suture, this bone T-shaped or Y-shaped, its teeth conical or tubercular. Air-vessel present. No pyloric cœca. Body covered with cycloid scales. Lateral line well developed, continuous or interrupted, often angularly bent. Dorsal fin continuous, spinous portion usually long, spines rather slender, 3 to 20. Anal like rayed dorsal, spines 2 to 6. Ventrals thoracic, I, 5, inserted below pectorals, latter sometimes thoracic.

The existing forms comprise about 60 genera, largely in tropical seas. Their dentition is admirably adapted for crushing the shells of mollusks, upon which most of them feed. About 11 extinct genera have been described, and some few species referred to several of the existing genera.

Genus PHYLLODUS Agassiz.

Phyllodus Agassiz, Poiss. Foss., II, pt. 2, 1844, p. 238. Type *Phyllodus toliapicus* Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, IV, 1901, p. 546.
Paraphyllodus Sauvage. Bull. Soc. Geol. France (3) III, 1875, p. 615. Atypic.

Pharyngeal dentition compact, tritoral, leaf-shaped, showing pile of successional teeth beneath each functional tooth, and middle teeth much larger than marginal teeth. Upper pharyngeal bones apparently fused together with lower pharyngeals.

This extinct genus is only known from the pharnygeal dentition. About 20 or more species have been described.

PHYLLODUS CURVIDENS Marsh.

Phyllodus curvidens Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 229. *Miocene Marl, near Shiloh, Cumberland Co.*
Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Miocene of Cumberland Co.)

Central portion of pharyngeal dental plate with very thick teeth, longest of which considerably curved, so that crushing surface of plate transversely concave. (From Marsh.)

Marsh says this species is readily distinguished by the unusual thickness of the teeth and the longest being considerably curved.

Formation and locality. Known from the Miocene marl near Shiloh [Kirkwood, K.] in Cumberland County. Not seen by me.

PHYLLODUS ELEGANS Marsh.

Phyllodus elegans Marsh, Proc. Amer. Ass. Adv. Sci., 1869, p. 228. *Eocene Greensand at Farmingdale, in Monmouth Co.*

Pharyngeal dental plate obtusely triangular, small, and triturating surface a little convex. Central teeth enlarged, circular,

well depressed or disk-like with central portion well pressed down, giving each tooth appearance of shallow cup. Only rims of each tooth covered with smooth enamel. Though most all teeth circular they vary into irregularities of circular design. Marginal teeth all smaller, similar, only with triturating surfaces less concave, and enameled marginal ring less defined, so enamel extends equally over concave median portions. Successional teeth equally enlarged median as seen from lower sur-

FIG. 108.—*Phyllodus elegans* Marsh. Monmouth Co.

face, as they are above, and marginal teeth also correspondingly reduced. Longest diameter 18 mm.

The above-described example agrees with Marsh's account, which states the lateral or smaller teeth to be rather few.

Formation and locality. Known only from the type ascribed to the Eocene greensand at Farmingdale (A. J. Smith), and presented to the Yale Museum, and another example in the Academy from Monmouth County (P. D. Knieskern), most likely from the same horizon, though this is not given. [See comment on page 180, K.]

INDEX.

Names in italics represent synonyms.

Z.

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 5

The Mineral Industry of New Jersey for 1910

BY

HENRY B. KÜMMEL

AND

S. PERCY JONES

TRENTON, N. J.
MacCrellish & Quigley, State Printers, Opposite Post Office.
1911.

CONTENTS.

Letter of Transmittal.

TRENTON, N. J., September 1st, 1911.

The State Printing Board,
Trenton, New Jersey.

GENTLEMEN—I hereby request that the State Printing Board order the publication of 1,800 copies of a Bulletin on the Mineral Industry of New Jersey for 1910, the manuscript of which is now ready. The publication of this report has been approved by the Board of Managers of the Geological Survey, and favorable action by the State Printing Board is requested as provided by Chapter 46, Laws of 1910. The printing contract for 1910–1911 provides for such Bulletins of the Geological Survey as shall be ordered by your board.

Respectfully yours,
HENRY B. KÜMMEL.
State Geologist.

STATE OF NEW JERSEY,
OFFICE OF COMPTROLLER OF THE TREASURY.
TRENTON, September 6th, 1911.

Henry B. Kümmel, Esq.,
State Geologist,
Trenton, N. J.

DEAR SIR—At a meeting of the State Printing Board, held September 5th, 1911, the request contained in your communication of the 1st inst., relative to the printing of 1,800 copies of a Bulletin on the Mineral Industry of New Jersey for 1910, was granted.

Very respectfully,
E. J. EDWARDS.
Comptroller, as Secretary, State Printing Board.

THE MINERAL INDUSTRY OF NEW JERSEY FOR 1910.

BY HENRY B. KÜMMEL AND S. PERCY JONES.

The collection of statistics of the mineral production of New Jersey was made in co-operation with the United States Geological Survey, in order that producers might not be troubled by requests for information from two organizations.

The returns, compared with those of the preceding year, indicate increased activity along most lines. The pottery branch of clay products exhibits the largest increase in any one industry, the sales for 1910 exceeding those in 1909 by $797,313.

The total value of the mineral industry for 1910 amounted to $35,184,692, distributed as follows:

VALUE OF THE MINERAL INDUSTRY IN 1910.

	Value.	*Per Cent. of Whole.*	*Increase or Decrease Compared to 1909.*
Iron Mining	$1,582,213	4.49	$24,796 D
Zinc Mining,	7,417,182 (*a*)	21.08	
Clay and Clay-Working Industries,	18,492,102	52.05	625,452 I
Stone,	1,704,112	4.84	61,313 I (*c*)
Sand and Gravel,	1,139,275	3.23	203,902 I
Portland Cement,	3,067,265	8.71	254,103 I
Lime,	128,964	.36	17,437 D
Mineral Water,	133,739	.38	6,114 I
Sand-lime Brick,	23,811	.07	1,886 I
Mineral Paints, Coke, Greensand Marl,	1,496,019 (*b*)	4.24	
Total,	$35,184,692		

a. Value of the recoverable output figured as metallic zinc.

b. Combined in order to conceal individual production of coke and mineral paints.

c. This comparison does not apply to slate, talc and soapstone.

IRON MINING.

The iron ores mined in New Jersey in 1910 were magnetite and limonite, or brown hematite. Only a small percentage of limonite was produced, the industry at present being practically confined to the magnetites.

The magnetite ores occur in a belt of pre-Cambrian rocks, traversing the northern part of the State. By far the most important deposits are found as interleaved layers of magmatic origin in gneisses. Workable ore bodies of lesser importance occur in a crystalline limestone associated with the gneisses, and at some points magnetiferous pegmatites have been mined for their ore contents. The occurrence of these ores has recently been fully discussed and all mining operations described by Dr. W. S. Bayley.[1] Those interested in the iron mines of New Jersey are referred to this report for further information.

In view of the opinion sometimes expressed that the end of iron mining in New Jersey and other eastern States was not far distant, attention may well be directed to Dr. Bayley's very conservative estimate of good ore still capable of being mined from all the points already known in New Jersey to be 35,000,000 tons, or nearly twice as much as has already been mined. If, in addition to these deposits of ore which can be mined without concentration, there should be added the vast amount of lean ore which must be concentrated to be of value, the total quantity of ore, available under economic conditions which may fairly be expected some day to prevail, must be estimated in the hundreds of million tons.

During 1910, the iron mining industry showed a slight fluctuation from that of 1909, there being a very small falling off in production.

The following mines were operated during all or a portion of the year: Ahles, Shoemaker, Washington, Mount Hope, Richard, Hude, Hurd (at Wharton), Hoff, Wharton, Orchard

[1] Bayley, W. S. Report on Iron Mines and Mining, Vol. VII. Reports of the Geological Survey of New Jersey.

and Peters. The ore produced amounted to 521,832 long tons, all being magnetite except the product of the Ahles mines, which, properly classed, is a manganiferous brown ore, and that of the Shoemaker mine, which is limonite. The value of the ore at the mines was $1,582,213, the average value per ton being $3.03. The returns from all the mines but two reported the percentage of metallic iron in the ore as varying from 54.6 per cent. to 59 per cent.

In addition to the production given above, the ore undisposed of at the various mines at the close of the year amounted to 17,567 long tons.

A comparison of the statistics for 1910 with those of 1909 shows a decrease in production of 21,688 tons, a little less than four per cent. The figures indicate, however, an average value per ton in 1910 of $3.03, as against $2.94 in the preceding year.

IRON ORE MINED SINCE 1870

Previously reported,	18,462,228
Mined in 1910,	521,832

ZINC MINES.

According to statistics obtained by the United States Geological Survey, 308,353 tons of crude ore were sent to the concentrating mills, from which 263,606 tons of concentrates were obtained. In addition 67,324 tons of crude ore were sent to the smelters. Figured as metallic zinc, the total recoverable output was 137,355,219 pounds of spelter valued at $7,417,182.

Mr. R. M. Catlin, superintendent of the New Jersey Zinc Company mine, at Franklin Furnace, reports 339,434 tons of ore hoisted in 1910. This is a decrease of 88,869 tons from the preceding year. There was, however, an increase of about 8 per cent. in the tonnage of ore separated.

The Palmer shaft has been completed and is now the working shaft for the entire product of the mine. With these new facilities all ore required by the mill is now delivered in the day,

so that the night shift in the mine can be dispensed with. Electric pumps have been installed on the 300-foot level to dispose of the surface water from the open cut. Electric haulage has been in satisfactory operation on the 300, 750, 950 and 1,150-foot levels.

A change house has been constructed at the Palmer shaft, and over half a million feet of timber was placed during the year. A hospital was completed by the company in 1908, and with this and a dispensary the needs of patients are provided for.

ORE MINED SINCE 1880.

Previously reported,	4,165,350
Mined in 1910,	339,434

CLAY AND CLAY-WORKING INDUSTRY.

New Jersey continues to lead in the production and sale of raw clay, and ranks third in the value of its manufactured clay products. The statistics of the clay-working industry of the United States in 1909, compiled by the United States Geological Survey, show that in that year New Jersey ranked first in fireproofing;[1] second in architectural terra cotta; second in tile, other than drain; third in front brick; fourth in fire brick, and fourth in common brick.

It ranks second in the total value of all classes of pottery ware, being exceeded in this branch of the clay-working industry by Ohio only.

In 1909, it was first in china delft and Belleek ware (about 61 per cent. of the whole); first in sanitary ware (about 72 per cent. of the whole), and second in porcelain electrical supplies.

The total value of clay products, exclusive of raw clay, in 1910 was $17,834,297 as against $17,172,094 in 1909, an increase of 2.6 per cent.

Raw Clay.—The most valuable clays of New Jersey, including the fine grades of fire clay, paper clay, ball clay, etc., are con-

[1] In these and following comparisons with other States it is necessary to use figures for 1909, as statistics for 1910 from other States are not available.

fined chiefly to the Raritan formation—the lowest member of the Cretaceous. This occurs in a broad belt extending across the state from the Raritan Bay to Trenton and Bordentown, and a much narrower strip along the Delaware River to Salem County. Much of this area, however, is covered by sand and gravel of later deposition, too thick at many localities to permit the exploitation of the underlying clay beds.

Clay suitable for the manufacture of common brick, drain tile and red earthenware, occurs in the other members of the Cretaceous and also in the Tertiary and Pleistocene. At several localities, clays of glacial origin are used for making brick.

The most extensive development of the clay-mining industry has taken place in the northeastern portion of Middlesex County, in the Woodbridge-South Amboy district.

The largest percentage of the more valuable clays are dug at this locality, while lesser quantities are mined in Burlington, Mercer and Camden counties. Common-brick clay is dug at numerous localities throughout the state, and clay for high-grade pressed brick is mined at a number of points in Monmouth, Ocean and Burlington counties.

By far the largest amount of clay mined in New Jersey is manufactured by the miner, and the figures under the head of "raw clay" show only that sold in the raw state. This is chiefly fire clay. A very large production of clay appears only in the statistics of manufactured products, principally as brick and tile.

Of the raw clay mined a large percentage is exported to various other states, where it is used in the manufacture of a variety of clay products.

In 1909, New Jersey reported 18.99 per cent. of the quantity of clay produced and sold in a raw state and 20.13 per cent. of its total value. The production for that year was 410,103 short tons, valued at $694,566. Of this 78.14 per cent. was fire clay, the value of which was 79.85 per cent. of the total value.[1]

During 1910, the clay mined and sold raw amounted to 405,591 short tons, valued at $657,805.

The various kinds of clay mined, the number of producers, the tonnage and value are shown in the following table.

[1] Figures from Mineral Resources of the United States, U. S. Geol. Sur.

KINDS OF CLAY MINED AND SOLD IN 1910.

	No. of Producers.	*Amount in Short Tons.*	*Value.*	*Average Per Ton.*
Ball Clay,	3	2,896	$17,376	$6.00
Fire clay, including sagger clay,	30	286,854	468,890	1.63
Stoneware clay,	8	21,099	45,171	2.14
Brick clay,	8	30,645	28,683	.93
Miscellaneous clay,[1]	14	64,097	97,685	1.52
		405,591	$657,805	$1.62

Pottery Industry.—The statistics of the pottery industry show a gratifying increase in the production over that for the preceding year. The total production of all classes of pottery ware in 1910 amounted to $8,588,455, as against $7,791,136 in 1909, an increase of 10.23 per cent. Fifty-nine firms reported production.

The following table gives the value of the different classes of ware manufactured and sold in 1910, togther with the statistics for 1909, for comparison.

	1909.[2]	*1910.*
Red earthenware,	$36,573	$26,529
Stoneware, yellow and Rockingham ware,	66,293	55,734
White ware, including C. C. ware, white granite, semi-porcelain ware and semi-viterous porcelain ware,	1,242,361	1,345,156
China, bone china, delft and belleek ware,	1,082,398	1,131,412
Sanitary ware,	4,341,040	4,955,066
Porcelain electrical supplies,	823,056	874,013
Miscellaneous,	199,415	200,545
Total value,	$7,791,136	$8,588,455

Trenton, which is the first in rank of the pottery centers of the United States, showed several new firms reporting production in 1910. Here is manufactured about ninety-three per cent. of the pottery products of the State.

[1] Includes Rockingham clay, pipe clay, terra-cotta clay, so-called Kaolin, &c.
[2] Figures from Mineral Resources of the United States, U. S. Geol. Survey.

All the white-ware, including C C ware, white granite, semi-porcelain and semi-vitreous porcelain ware; all the china, bone china, delft and belleek ware; all the porcelain electrical supplies, and also nearly all of the sanitary ware made in the State are reported from Trenton.

The value of its production in 1909 was 23.11 per cent. of that of the whole country.

So far as New Jersey clay is used for pottery manufacture, excepting that used for common red earthenware and saggers, it is obtained from the lower beds of the Cretaceous, though deposits occur in the Tertiary and Pleistocene formations that might possibly be utilized as stoneware clay. The clay for potteries comes principally from the Woodbridge-South Amboy district of Middlesex County.

The method of mining is usually surface working, pits of convenient size being sunk through the good clay in the bed. Shaft mining has been employed at a few points where the overburden is very heavy.

The lower-grade clays are mined on a more extensive scale, banks or large pits being worked and steam shovels sometimes employed.

No washing of clay at the mines before marketing is done, except in the case of ball clay.

Brick and Tile.—The brick and tile industry is well developed at many points in the State. The various branches of the industry are, however, somewhat localized. Building bricks are made in large numbers at Hackensack and Little Ferry, Cliffwood and Keyport, and also at Trenton and Camden; fire brick at Woodbridge, Sayreville and South River; architectural terra cotta chiefly at Perth Amboy, South Amboy and Rocky Hill.

An inexhaustible supply of good raw material, and the proximity of large centers of population have combined to make brick manufacturing a thriving industry in New Jersey for over half a century. As will be seen from the table below, the value of the common brick produced is more than double that of any other variety. Fire brick show a valuation of a little less than half that of common brick, and front and enameled brick are next in relative order of importance.

The value of the architectural terra cotta is one of the large items of the figures of the brick and tile industry. In 1909, New Jersey was a close second to Illinois, which reported the largest production of all the states in this industry.

Fireproofing is another important product of this branch of the clay-working industry, New Jersey, as previously stated, ranking first among the States in the output of this in 1909.

The chief facts regarding the production of brick and tile are summarized in the following table:

PRODUCTION OF BRICK AND TILE IN 1910.

	No. of Plants Producing.	*No. of M.*	*Value.*	*Aver. Value. per M.*
Common Brick, ...	67	401,103	$2,215,628	$5.55
Front Brick, ...	9	47,651	609,845	12.80
Fancy Brick, ...	2	......	246,257	
Enameled Brick, ...	2			
Fire Brick, ...	13	38,349	1,001,063	25.96
Total Brick, ...			$4,072,793	
Drain Tile, ...	7	......	$23,147	......
Architectural Terra Cotta, ...	5	......	2,000,039	......
Fire-proofing and Hollow Blocks, ...	9	......	1,582,101	......
Tile (not drain), ...	9	......	1,199,113	......
Miscellaneous,[1]	6	......	368,661	......
Total All Products, ...			$9,245,854	

The total of all products in 1909 was $9,380,958.

In 1910 there was a slight falling off in all kinds of brick, except fire brick (in which there was an increased production), and a decrease in the production of drain tile.

The production of architectural terra cotta and of fireproofing was slightly in excess of that of the previous year.

STONE INDUSTRY.

The stone industry of New Jersey consists in the quarrying of building and monumental and paving stone, and also the quarry-

[1] Includes glass-melting pots, gas-furnace linings, underground conduits, retorts and muffles, sewer pipe, chimney brick, wall coping and stove lining.

ing and crushing of large amounts of stone for road material, railroad ballast and concrete work. The production of crushed stone, chiefly trap rock, constitutes an important industry, but quarrying for building monumental purposes has not received the attention for some years that it undoubtedly merits.

The statistics for 1910 for granite show that over fifty per cent. of the production was crushed, and in the case of trap rock, with the exception of a small percentage that was made into paving blocks, practically the entire production was reported as crushed stone.

Stone embracing a wide range of material and suitable for all the purposes above mentioned occurs at numerous localities northwest of a line passing through Trenton diagonally across the narrowest part of the State, and separating the low-lying Coastal Plain from the hilly region to the north. Granites, gneisses and crystalline limestone are found in the Highlands and belts of limestone and slates in the Kittatinny Valley.

Trap rock and brown, gray and light-colored sandstone occur in the Newark (Triassic) system. This forms a belt which extends across the northern part of the State, varying in width from thirty-two miles along the Delaware River to fifteen miles at the New York State line.

The trap rock so extensively used in New Jersey for road metal is obtained from the Newark system, its distribution therein being generally that of long areas of relatively narrow lateral dimensions. Some trap rock also occurs as dikes in the gniesses of the Highlands.

As previously stated, nearly all the trap rock quarried is crushed, its toughness and lack of rift or definite planes, along which a stone cleaves with more or less ease, rendering the working of it up into building material to any large extent too expensive.

In addition to the varieties of stone already mentioned, a conglomerate that gives a pleasing effect as a building stone occurs in the vicinity of Greenwood Lake in the Highlands, and in the southern part of the State semi-consolidated sandstones and conglomerates are utilized locally for building purposes.

The total value of the production of all classes of stone in 1910, exclusive of slate, talc and soapstone, amounted to $1,675,174. Of this nearly 76 per cent. was trap rock, 4¾ per cent. granite, 6¾ per cent. sandstone and a little more than 13 per cent. limestone.

In 1909 the total production, exclusive of slate, talc and soapstone, was $1,613,861.

The table below shows the value of the stone used for various important purposes, with the percentage in each case of the total value.

USES OF STONE AND VALUES, 1910.

Building stone,		$90,338	(5.3 %)
Rough,	72,175		
Cut or dressed,	18,163		
Paving blocks,		61,376	(3.6 %)
Crushed stone,		1,278,609	(73.8 %)
Road metal,	739,727		
R. R. ballast,	269,760		
Concrete,	269,122		
Blast furnace flux,		199,532	(4.5 %)
All other uses,[1]		74,259	(4.3 %)

Trap rock—The trap rock quarried in 1910 amounted to about 73 per cent. of the total value of the production of stone in the State. Of this 56½ per cent. was sold for road construction. Smaller, but considerable amounts, were used for railroad ballast and for concrete.

The following table gives the chief facts regarding the production of this class of stone:

PRODUCTION OF TRAP ROCK, 1910.

	No. of Producers.	*Amount Short Tons.*	*Value.*	*Aver. Price Per Unit.*
Building stone (rough and dressed),	8	7,308	$7,989	$1.12
Rubble,	3	2,541	3,073	1.20
Riprap,	2	2,095	1,298	.61⅔
Road metal,	53	856,770	721,761	.84
R. R. ballast,	14	355,460	223,817	.62½
Concrete,	36	318,137	229,906	.72
Paving blocks,	9	(2,114 M)	60,976	28.82
Other uses,	6	5,905	8,892	1.50
		1,548,216[2]	$1,257,712	

[1] Includes roofing slate and talc and soapstone.

[2] Paving blocks not included.

Granite.—Granite is quarried at a number of localities in the Highlands, several varieties of different colors and texture being worked.

A pink granite is quarried at Pompton, and a pinkish-gray stone has been worked near Charlotteburg and Waterloo. Gray and gray-white are common tones of color, and, in addition to granite, both light and dark-colored gneisses are common throughout the Highlands. The gneisses are quarried at a number of localities and crushed for railroad ballast, concrete, and other purposes.

Nine quarries reported production in 1910.

The total output was valued at $80,105, as against a production of $60,175 in 1909, an increase of 33 per cent.

The table given below shows how the production was divided. It will be noted that only about 13 per cent. was used for building and monumental purposes. Over 50 per cent. was crushed and sold for railroad ballast.

Several quarries, yielding building and monumental stone, that were idle in 1910 have recently become active, and it is probable that this branch of the granite industry will show larger returns for 1911.

PRODUCTION OF GRANITE IN 1910.

	No. of Firms Reporting.	*Value.*
Sold Rough—Building,	5	$6,772
Sold Rough—Monumental Work,	1	
Sold Rough—Other Purposes,	2	2,465
Dressed—Building,	4	1,338
Paving Blocks,	1	
Rubble,	1	1,730
Riprap,	1	
Crushed Stone for Road Building,	1	
Crushed Stone for Railroad Ballast,	1	66,924
Crushed Stone for Concrete,	3	
Other purposes,	2	876
		$80,105

Sandstone.—Under the head of sandstone are included brownstone, gray and white sandstone, black argillite and quartzite, all of which are quarried in New Jersey.

It will be noted from the figures given below that this is the

only variety of stone quarried in the State at present, the maximum percentage of the production of which is utilized for building purposes.

Practically all of the sandstone quarried is from the Newark system. The area of this is in the smoother, middle section of the State, and near the large centers of population, affording the chief markets. Brownstone, the reddish-brown to dark chocolate-colored sandstones of this formation, once so popular for building purposes, is now used to a limited extent only, but in the sandstone district white, creamy and light gray-colored stone abounds and offers promise of a steady building-stone industry.

The value of the sandstone quarries in 1910 was $112,650 as against $189,098 for the previous year, a decease of 40 per cent.

The different uses and value of each class of material quarried are shown in the following table:

PRODUCTION OF SANDSTONE IN 1910.

Uses.	*No. of Producers.*	*Value.*	*Per Cent.*
Building Stone, Rough,	12	$56,099	50
Building Stone, Cut or Dressed,	4	16,600	15
Concrete,	3	27,010	24
Curbing,	2		
Flagging,	1		
Riprap,	1	12,941	11
Rubble,	1		
Road Metal,	2		
		$112,650	

Limestone.—The limestone statistics do not include the amounts nor value of that used in the manufacture of lime and Portland cement, this portion of the production appearing in the statistics of those industries.

PRODUCTION OF LIMESTONE IN 1910.

Uses.	*No. of Producers.*	*Amount Short Tons.*	*Value.*	*Average Per Unit.*
Road Metal,	4	33,606	$22,806	$0.67½
Concrete,	4			0.68
Blast Furnace Flux,	9	419,983	199,532	0.47½
Building Stone,	3		2,369	
Other Uses,	2			
			$224,707	

As will be seen from this table, the stone used for fluxing purposes forms the largest percentage of the product. Another large item of limestone production, not showing in the figures above, is that used for raising the lime content in the manufacture of Portland cement and the cement rock used in making this material. The latter is an earthy limestone containing from 60 to 70 per cent. of lime carbonate, and is obtained chiefly in Warren County. About 275,718 tons of limestone were quarried during the year in connection with the Portland cement industry. In addition a smaller tonnage was produced for the manufacture of lime.

The value of the limestone production in 1909 was $224,017.

Slate, Talc and Soapstone.—As there were less than three producers in each of these industries, the values for all are totaled in order that the figures of individual producers may not appear.

The slate quarries reporting operations are in Sussex County and the production is used entirely for roofing. As, however, the most of the New Jersey slate is a hard slate, it might also be utilized to advantage for other purposes such as flagging, steps, etc., where resistance to wear and weathering are important qualities.

The combined value of slate, talc and soapstone in 1910 was $28,938.

SAND AND GRAVEL.

The value of the production of sand and gravel in 1910 was $1,139,275, and in 1909 $935,373. The largest gains were in molding and building sands.

Owing to the fact that a large number of small producers keep imperfect records of their production, some selling by wagon loads of varying weights, the compilation of accurate statistics for sand and gravel is more difficult than in the case of other mineral products. The returns, however, from the large miners are usually fairly complete.

Much of the sand dug is reported in cubic yards and wagon loads, as well as in tons. A cubic yard varies in weight from 2,300 to 3,000 pounds, according to the condition of the sand, and a wagon load ranges from a 1,000 to 3,000 pounds. Owing to this indefiniteness in the units of measurement only the values are here given, except in the case of glass sand, which is sold by the ton.

Practically all the sand reported in New Jersey is natural sand, as distinguished from crushed rock, only a very small amount of the latter being produced.

Sand is utilized for a variety of purposes and is designated in trade terms according to the uses for which it is produced, as building sand, molding sand, glass sand, furnace sand, filtration sand, etc.

The first two varieties named are the most important commercially, while sand for glass manufacture, excepting that used for some of the common grades of glass, must be a very pure sand and practically free from any coloring ingredients.

The price per ton varies from as low an amount as 10 cents (in the bank) to $1.50 or more, depending on the variety of sand, the facilities for transportation, and treatment it may have undergone after mining, such as screening, washing or drying. Glass and molding sands usually sell for more than the other varieties.

The table given below shows the chief facts regarding the production:

PRODUCTIONS OF SAND AND GRAVEL IN 1910.

	No. of Producers.	*Value.*
Building sand—		
Concrete sand.	32	$216,840
Mortar sand,	12	63,053
Unclassified,	19	59,795
Molding sand—		
Brass molding,	2	2,988
Unclassified,	3	
Steel molding,	19	134,911
Iron molding,	23	119,948
Core molding,	13	178,613

	No. of Producers.	Value.
Glass sand,	9 (87,680 tons)	61,078
Fire sand,	10	32,562
Engine sand,	4	9,666
Furnace sand,	6	9,246
Filtration sand,	4	25,067
Other sand,	10[1]	86,316
Total sand,		$1,000,683
Concrete gravel,	16	52,025
Road-making gravel,	15	86,432
Other gravel,	2	135
		$138,592
Total sand and gravel,		$1,139,275

PORTLAND CEMENT.

This industry showed increased production compared to the preceding year both in quantity and value. The total output for 1910 was 4,184,698 barrels, valued at $3,067,265, or 0.73 per barrel in bulk, as against 4,046,322 barrels valued at $2,813,162, or 0.69 per barrel, in 1909. Expressed in percentages this is an increase of something over 3 per cent. in amount of production and 9 per cent. in value.

The actual production was far short of the working capacity of the plants reporting. All were either closed down during a portion of the year on account of over-production or ran considerably under their capacity.

The industry was confined to Warren County, and the raw materials used were limestone and cement rock.

LIME.

The stone used in making lime is not included in the statistics of limestone in the stone industry, in order that there may not be a duplication of value.

[1] Includes sand for grinding and polishing, asphalt, grading and filling, paving and other miscellaneous uses.

The production of lime in 1910 amounted to 34,335 short tons, valued at $128,964. There was a slight falling off from the amount burned in 1909, the figures for that year showing 38,014 tons, valued at $146,401. This was a decrease of 3,679 in tonnage and $17,437 in value. The average price per ton in 1910 was $3.75 and in the preceding year $3.85.

The white, crystalline pre-Cambrian limestone is used in making over half of the lime manufactured. That produced from the blue magnesian limestone of later geological age is sold almost entirely for fertilizing land.

The most important data concerning the production of lime are shown in the following table:

PRODUCTION OF LIME IN 1910.

Uses.	*No. of Producers.*	*Amount Short Tons.*	*Value.*	*Value Per Ton.*
Fertilizer,	16	15,254	$43,973	$2.88
Quick Lime,	4	856	2,080	2.43
Dealers,	2	....	....	4.55¼
Paper Mills,	1	18,225	82,911	
Chemical Works,	1			
		34,335	$128,964	$3.75

Fuel.—All the plants reporting used coal for fuel except three that burned with wood. One ton of coal to 100 bushels of lime is approximately the average of the figures for the blue or magnesian limestone, while a larger amount of fuel is required for burning the crystalline or non-magnesian limestone.

SAND-LIME BRICK.

Sand-lime brick were manufactured in 1910 at Penbryn and West Palmyra in Camden County and at Rockaway in Morris County. Three plants reported.

The total production of all classes of brick was 2,824 M., valued at $23,811.